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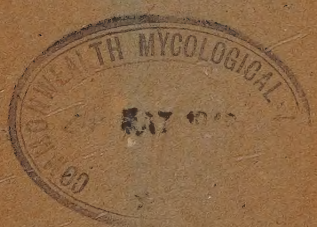
TRELAWNEY TOBACCO RESEARCH STATION

ANNUAL REPORT
for 1947



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SALISBURY S. RHODESIA

TRELAWNEY TOBACCO RESEARCH STATION

ANNUAL REPORT
for 1947

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Report of the Tobacco Research Board for the Year ended 31st December, 1947.

THE BOARD

The present personnel of the Board is as follows:—

Nominees of the Honourable the Minister of Agriculture and Lands:

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Messrs. Jeffreys and Hoskens-Davies joined the Board in October vice Messrs. A. M. Hutchinson and Capt. R. D. James, M.C.

The Tobacco Research Board would like to place on record its appreciation of the services of Messrs. Hutchinson & James during their periods of office.

STAFF

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Agronomist	J. B. P. JONES, N.D.A., Dip. Agric., U.C.W.
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Farm Foreman	F. E. SCAMELL.
Auditors	Messrs. SPEIGHT, GOLDBY & WEBBER.
Secretary	A. J. G. TALBOT.

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I.

General

Weather Conditions. The season was unusually dry, the rainfall being the lowest recorded since the Station opened (see Table I). A heavy rain fell on November 23rd, but was followed by such hot weather that plantings made after the rain were a complete loss. The next planting rain on December 27th was followed by a few days of good conditions and planting was completed during this period.

Growing conditions were, on the whole, good except for a hot, dry spell in February which caused severe wilting and considerable damage by leaf scorch. It may be mentioned here that the rain fell in isolated showers for the most part and that rains recorded at the Laboratory in many cases did not reach the lands.

All the experimental crop gave good yields of high quality tobacco, but plantings on heavier soils gave poor quality in spite of good growth. These lands were somewhat unfortunate as regards rain, and considerable damage was caused by excessive wilting. It was noticed, however, that the tobacco remained green and was very slow in ripening; this is typical of high nitrogen and low phosphate nutrition. These lands received only 10 to 20 lbs. per acre P_2O_5, whereas it has been shown on the Station that in dry seasons dressing up to 80 lbs. per acre P_2O_5 are beneficial. It is very probable that the poor quality and "drought-stricken" appearance was due to insufficient phosphate rather than to climatic conditions. This view was substantiated by the fact that the main beneficial effect of compost last season was, apparently, the supply of additional phosphate.

Insect Pests. White grubs and wire worms again caused very considerable damage; the attack commenced very early in the season. In tobacco planted on 15th November a considerable loss of stand due to white grubs was observed within a few days after planting. Early planting does not necessarily avoid the white grub attack. It was noticed that the harder, tougher plants not only stood up to weather conditions better than the so-called "ideal plants," but also seemed less attractive to white grubs and wire worms. One series of seed-beds, noted as being ready for planting on 30th November, was held back with little further growth until 27th December by reducing the water supply to practically nil. The plants which were badly wilted and scorched up to the time of planting gave the best stands and highest yield and quality compared with others planted out at the same time.

Disease. There was very little in the way of disease. Some angular spot appeared on tobacco damaged by hail, but under the very low rainfall conditions did not spread.

Barn rot again appeared to be controlled as soon as it appeared by curing in the manner described in previous reports.

The mosaic infection was again very slight.

Presentation of Results. The results have been evaluated and tabulated in the same manner as in previous seasons. The same standard prices based on samples were used. The actual selling price was a little under five times the average prices given.

Acknowledgment. We are again indebted to the Imperial Tobacco Company and to Messrs. J. Reid Rowland & Co. for classification of samples.

TABLE I.

RAINFALL AND SUNSHINE

	November.		December.		January.	
	Rainfall, Inches.	Hours of Sunshine.	Rainfall, Inches.	Hours of Sunshine.	Rainfall, Inches.	Hours of Sunshine.
1	—	10.9	—	5.7	0.33	1.2
2	—	6.3	—	10.9	0.01	4.8
3	—	7.1	—	11.0	0.42	2.8
4	0.31	9.1	—	10.4	0.26	3.8
5	—	10.8	—	9.8	0.06	4.9
6	—	10.8	—	4.5	0.19	7.2
7	—	10.9	0.11	7.9	0.96	9.5
8	—	6.1	—	10.0	—	10.9
9	—	5.8	—	4.8	—	9.8
10	0.39	1.1	0.03	4.4	0.75	11.0
11	0.09	4.0	—	7.1	0.01	10.2
12	0.30	6.3	—	8.5	—	7.8
13	—	2.2	—	5.3	—	9.2
14	0.13	3.5	0.08	2.1	—	9.7
15	0.13	0.6	—	2.2	0.25	5.9
16	0.07	3.8	0.03	9.5	—	7.9
17	0.06	4.1	—	10.3	0.03	6.5
18	—	9.6	—	9.4	0.02	6.8
19	0.33	4.5	—	8.9	—	5.0
20	0.01	8.7	—	6.2	—	7.8
21	—	6.8	0.14	7.6	—	6.4
22	—	2.8	—	1.4	0.04	6.8
23	1.57	0.7	—	4.2	0.22	7.0
24	—	1.8	0.15	2.5	0.37	5.2
25	—	5.3	0.16	1.0	0.83	6.1
26	—	6.8	—	0.4	0.31	4.8
27	—	6.2	0.97	3.1	0.14	4.0
28	—	7.2	2.60	3.8	0.02	7.8
29	0.12	5.3	0.12	2.8	—	7.4
30	—	6.4	0.14	3.6	0.12	10.8
31	—	—	0.02	5.5	—	9.6
Total	3.51	175.5	4.55	184.8	5.34	218.6

DURING SEASON 1946/1947.

February.		March.		April.	
Rainfall. Inches.	Hours of Sunshine.	Rainfall Inches.	Hours of Sunshine.	Rainfall Inches.	Hours of Sunshine.
0.23	8.3	0.04	4.0	0.99	3.7
0.03	0.4	0.05	4.6	—	4.6
0.32	0.9	0.05	7.8	—	4.7
0.69	4.1	0.04	0.7	—	3.3
—	10.0	—	2.2	—	9.0
—	7.7	0.27	2.5	—	4.6
—	9.9	0.82	9.4	—	10.9
0.08	9.1	0.01	5.0	—	11.2
—	6.1	—	9.9	—	10.9
—	9.5	—	9.3	—	10.4
—	8.2	—	8.1	—	10.6
—	6.8	—	9.5	—	11.0
—	9.3	0.17	4.2	—	11.0
—	9.8	—	9.0	—	10.1
—	10.3	—	8.1	—	7.0
—	8.9	0.03	5.5	—	2.5
—	6.2	0.40	6.1	—	6.8
—	4.7	0.88	3.1	—	8.6
0.02	5.9	0.25	3.9	—	9.6
0.24	5.5	—	7.1	—	9.8
0.25	6.0	—	10.4	—	3.4
1.09	2.5	—	10.7	—	4.4
0.01	6.3	—	8.4	—	8.2
0.18	4.0	—	6.7	—	9.4
—	8.9	—	6.2	—	9.7
—	6.7	—	6.8	—	9.9
0.19	6.5	—	3.6	—	7.2
0.52	2.7	0.11	2.0	—	9.3
—	—	0.12	1.7	—	8.1
—	—	0.01	3.5	—	2.4
—	—	0.04	4.1	—	—
3.85	185.2	3.29	184.1	0.99	232.3

TOTAL RAIN: 21.53 inches.

II

Agronomy

A. ROTATIONS (by J. B. P. Jones).

Two series of rotations started by Mr. Ellis came under tobacco. These were:—

H. A five-year course rotation, i.e., two seasons tobacco followed by three seasons of other crops, and then back to tobacco again.

J. A three-course rotation, i.e., two seasons tobacco followed by two seasons under other crops.

H. Five-Year Course Rotation. The following rotations were tested:—

	1941-42-43	1943-44	1944-45	1945-46	1946-47
1.	Tobacco	Rhodes Grass	Rhodes Grass	Rhodes Grass	Tobacco
2.	,,	Dhal	Dhal	Dhal	,,
3.	,,	Maize	Sunnhemp (P.U.)	Munga P.U.	,,
4.	,,	Cotton	Sunnhemp (P.U.)	Maize	,,
5.	,,	Maize	Fallow	Fallow	,,
6.	,,	Maize	Cotton	Velvet Beans (C.H.)	,,
7.	,,	Fallow	Fallow	Fallow	,,

P.U.: Ploughed under. C.H.: Cut for hay.

The soil was a light grey sand originally opened in 1941.

Other details were as follows:—

Dates of Ploughing Under of Rotational Crops.

Sunn Hemp	March 14/46
Munga	March 14/46
Maize	April 12/46
Dahl	June 20/46
Velvet Beans	March 14/46
Rhodes Grass	August 15/46

All plots were fertilised and treated in the same manner.

November 29, 1946. Plots hilled and fertilised at the rate of 150 lbs. per acre. 10—6—8 mixture applied.

December 27, 1946. Planted.

January 20, 1947. Re-filled.

January 23, 1947. 150 lbs. per acre, 10—6—8 mixture. The lay-out was a Latin square, plots being 1/40th acre in area.

Field Observations. Since there appeared to be considerable differences in the number of weeds growing in the various treatments, the plots were checked for weed growth on January 21st and February 5th.

Treatment numbers 2, 5 and 7 were found to have a much greater number of weeds than the remaining treatments, but the differences

were not so marked as in the five-course rotation described below. The plots were weeded between observations.

A check was made on January 19th—three weeks after planting—of the loss of stand due to soil insect pests, to determine whether any particular rotation rendered the soil more attractive to insects. The results, however, showed little differences, the average stand before refilling in each treatment being as follows:—

TABLE I.

Average Stand in Five-Course Rotation Three Weeks After Planting.

Treatment	1	2	3	4	5	6	7
% Stand	85	88	88	88	86	82	88

A statistical analysis of figures showed that the differences in stand were entirely fortuitous, and not due to preference on the part of the insects for any particular treatment.

The hills with missing or dead plants were then examined to determine what type of insect was responsible for the loss. In the great majority of cases the losses were due to either white grubs or false wire worms.

The relative losses are given in Table II.

TABLE II.

Loss of Plants Due to White Grubs and Wire Worms Three Weeks After Planting.

	Treatment						
	1	2	3	4	5	6	7
Loss due to white grubs	11	12	8	10	11	9	10
Loss due to wire worms	13	17	19	17	28	10	19

The statistical analysis of the figures again showed no differential infestation between treatments.

Considerable differences were noticed between the growth of tobacco following the various rotations. Nos. 1 and 2 Rhodes Grass and Dahl were outstandingly good. The colour of the tobacco following Dahl was much darker than that following Rhodes Grass. The Munga and Velvet Bean plots also looked well in the field, while the growth of the tobacco immediately following maize was noticeably poorer than the rest.

The results on the basis of yield and quality are summarised in Table III.

TABLE III.

Yields, Prices and Cash Values from Five-Course Rotations.

Treatment.	Yield.		Price.		Value.	
	Lbs. per acre.	% of mean.	Pence per lb.	% of mean.	Value per acre.	% of mean.
1	1,082	112.9	7.68	102.7	£34/13/-	116.6
2	1,080	112.8	7.48	100.1	£33/11/-	112.7
3	973	101.6	6.95	92.9	£28/ 4/-	94.6
4	848	88.5	7.28	97.4	£25/14/-	86.3
5	876	91.5	7.48	100.1	£27/ 7/-	91.8
6	980	102.3	7.50	100.7	£30/11/-	105.9
7	865	90.3	7.96	106.3	£28/ 9/-	95.5

F Significant at 1% and 5% points for yield, price and value.

	Yield.	Price.	Value.
Mean of treatments	958	7.47	£29/17/-
Standard errors	5.11%	0.62%	5.10%
Significant differences 5%	141 lbs.	0.13d.	£4/8/-
Significant differences 1%	190 lbs.	0.18d.	
Significant diff. % of mean 5%	12.7%	1.74%	14.8%
Significant diff. % of mean 1%	19.8%	2.40%	19.9%

Significant differences 5% Points.

Yield: 1 and 2 better than 4, 5 and 7.

Price: 7 better than 1, 2, 3, 4, 5 and 6.
1 better than 2, 3, 4, 5 and 6.
6, 2, 5 better than 3 and 4.

Value: 1 and 2 better than 3, 4, 5 and 7.
6 better than 4.

Discussion. Two of the rotations have given cash returns much higher than the fallow plots. These were No. 1 three years Rhodes grass and No. 2 three years dahl. No. 6, maize, cotton, velvet beans, gave a significantly better value per acre than No. 4, cotton, sunn hemp, maize. Fallow, on the other hand, gave an average price significantly higher than any of the other treatments. An examination of the leaf during grading showed, however, that the leaf from No. 1 treatment was of equally good quality, but that with the better growth and higher yield there was a higher percentage of medium and dark grades, resulting in a slight lowering in price.

The leaf following dahl and velvet beans was considerably harsher than that of treatments 1 and 7. Dhal as a rotation crop has one major drawback, that is its susceptibility to frost. Over the past three years practically all the dhal planted on the Station has been destroyed by frost.

The leaf from treatments 3 and 4, maize, sunn hemp, munga and cotton, sunn hemp, maize, was of poor quality, being harsh and brittle, with a considerable amount of discard. The results of this season and of previous seasons indicate that if sunn hemp is to be used in a rotation an appreciable interval must intervene between the sunn hemp crop and the following tobacco.

J. THREE-COURSE ROTATIONS.

This was the second series of three-year rotations to come under tobacco. The rotations used were the same as those reported on last season, except for No. 1, where two years purple top buffel had to be replaced by two years weed fallow owing to the failure of the buffel seed to germinate. The soil used was heavier than that reported on last year, and the previous history of the land was as follows:—

Opened 1937. Tobacco two seasons, dhal three seasons, tobacco two seasons, followed by the rotations mentioned below:—

	1944-45.	1945-46.	1946-47.
1.	Fallow	Fallow	Tobacco
2.	Sunn hemp P.U.	Maize	,,
3.	Maize	Sunn hemp P.U.	,,
4.	Munga P.U.	Fallow	,,
5.	Maize	Velvet Beans C.H.	,,
6.	Cotton	Sunn hemp P.U.	,,
7.	Fallow	Fallow	,,

P.U.: Ploughed under. C.H.: Cut for hay.

All plots were fertilised and treated in the same manner, the experimental details being as follows:—

21.11.46. 150 lbs. per acre 10—6—8 mixture applied.

27.12.46. Planted.

20.1.47. Re-filled.

23.1.47. 100 lbs. per acre 10—6—8 mixture.

The lay-out was a Latin square, plots being 1/40th acre in area.

Field Observations. As there were very obvious differences in the weed infestation between the various treatments, notes were taken on 20.1.47 and 4.2.47. The land was cleaned and cultivated between those dates. Treatments 1 and 7, both fallow plots, showed an outstandingly high infestation of weeds, followed closely by 4, munga, fallow. The weeds chiefly consisted of rapoko grass, and it is noteworthy that the heavy infestation was confined to the fallow plots, while clean cultivated crops and sunn hemp had greatly reduced the number of weeds. Two years fallow is evidently insufficient to allow the rapoko (*Eleusine indica*) grass seeds to die out.

A count of insect pests was made on 19.1.47, but there was no indication of differences between treatments.

The percentage stands at this stage are shown in Table IV.

TABLE IV.

Percentage Stand at Three Weeks in Three-Course Rotation.

	Treatment						
	1	2	3	4	5	6	7
% Stand	95	96	93	95	95	96	96

Observations made during the course of the growing season showed that the tobacco immediately following sunn hemp made the best growth, but the leaf was darker green and rank. Where maize intervened between the sunn hemp and tobacco a much finer type of tobacco resulted. Tobacco immediately following velvet beans (stubble ploughed under) was poor throughout, a result which is difficult to explain, more especially as this treatment gave a relatively high yield last season.

The results of this experiment on the basis of yield, price and value are given in Table V.

TABLE V.

Treatment.	Yield.		Price.		Value.	
	Lbs. per acre.	% of mean.	Pence per lb.	% of mean.	Value per acre.	% of mean.
1	966	105.5	8.04	105.9	£32/12/-	112.0
2	984	107.4	7.25	95.5	£29/16/-	102.0
3	869	95.0	7.14	94.1	£26/ 2/-	89.8
4	911	99.5	8.00	105.4	£30/ 7/-	104.3
5	794	86.7	7.89	103.9	£25/18/-	89.0
6	846	92.4	6.67	87.9	£23/14/-	81.4
7	1,036	113.2	8.15	107.4	£35/ 6/-	121.5

F Significant at 1% and 5% points for yield, price and value.

	Yield.	Price.	Value.
Mean of treatments	915	7.59	£29/2/-
Standard error	4.01%	3.75%	5.5%
Significant differences 5%	106 lbs.	0.82d.	£4/12/-
Significant differences 1%	143 lbs.	1.11d.	
Significant diff. % of mean 5%	11.58%	10.80%	15.62%
Significant diff. % of mean 1%	15.63%	14.62%	21.33%

Significant differences 5% points.

Yield: No. 7 better than 3, 4, 5 and 6.
No. 2 better than 3, 5 and 6.
No. 1 better than 5 and 6.
No. 4 better than 5.

Price: 7 better than 2, 3 and 6.
1 and 4 better than 3 and 6.
5 better than 6.

Value: 7 better than 2, 3, 4, 5 and 6.
1 better than 3, 5 and 6.
4 and 2 better than 6.

Discussion. Except for treatments 5 (maize, velvet beans), the results show considerable similarity to those of the previous season. The plots immediately following the sunn hemp gave low yields of poor quality tobacco. As mentioned above, the growth of the tobacco in these treatments (3 and 6) was more vigorous than the others, but much dead leaf occurred in the barns, while a great deal had to be discarded during grading, eventually bringing the yield below treatments which had shown less vigour in the field. The fallow plots again gave good results, but munga, fallow, did not show up as well as in the previous season. The general impression gained was that two years' interval for rotations between tobacco crops was not sufficiently long. It seems evident also that while land can be brought back into a reasonable state for tobacco by some form of grass crops, if cultivated or cash crops are to be grown, some method of rendering the soil suitable for tobacco must be devised. It is possible that this end might be attained by the use of compost.

FIVE-COURSE ROTATIONS UNDER INTERMEDIATE CROPS.

Another series of rotations similar to that described under H above was put under intermediate crops for the second year. The crops consisted of dhal, sunn hemp and cotton.

The dhal should have been planted the previous year, but owing to a failure of the seeding, had to be re-sown last season.

Seed was sown at the rate of 5½ lbs. per acre with 5 per hole at a 3 ft. x 3 ft. spacing. Growth was good, a complete cover being obtained within the year.

Cotton (following maize) sown 21.11.46 was spaced 3 ft. x 9 ins. with 2 plants per hill. The seeding was 15 lbs. per acre. The average yield was 328 lbs. seed cotton per acre.

Sunn hemp was broadcast at the rate of 35 lbs. per acre on November 21st, 1946. Germination was good, but at the second leaf stage it was severely attacked by sunn hemp beetles. In an attempt to control these, the plots were treated with Gammexane, D.D.T. and Lead Arsenate. As the results are of some interest, they are described below.

Dusts containing 0.5%, 0.4%, 0.33% and lower strengths Gammexane were applied at the rate of 8 ozs. per plot (1/40 acre), or 20 lbs. per acre.

5% D.D.T. powder was applied at the same rate, and Lead Arsenate at the rate of 2½ ozs. per 4 gallons water was sprayed on.

Gammexane at the rates of 0.5%, 0.4% and 0.33% all gave an excellent kill, while the 0.25% gave a lower but still good kill. The lower percentages of Gammexane showed a rapid falling off in effectiveness.

5% D.D.T. at the rate of 20 lbs. per acre was also very effective, the kill being equal to that of 0.5% and 0.4% Gammexane. The treated plots, which would almost certainly have been partially destroyed, were not re-attacked, and grew out to give a very good crop of sunn hemp.

A third five-year rotation was planted to intermediate crops in their third year. The planted crops were maize following sunn hemp ploughed under, velvet beans and munga.

As the maize plots could not be adequately guarded, only an estimate of yield could be made. It was considered that the yield was about 8 bags per acre.

Velvet beans (Somerset variety) following cotton, spaced 3 ft. x 3 ft. and planted 3 seeds per hole. The rate of sowing was 28 lbs. per acre. The average weight of hay was 2,388 lbs. per acre.

Munga, seeded at the rate of 20 lbs. per acre, gave a satisfactory crop. No manure was applied to any crop in the rotation, and fertiliser only given to the tobacco crop. High crop yields therefore could not be expected, and in future, crop rotations will be manured.

GRASS ROTATIONS.

Previous work at the Trelawney Station has pointed to some type of grass crop being the most suitable rotation for tobacco. It was decided, therefore, to lay down a series of rotations consisting of grasses only, to test not only the effects of various grasses on the succeeding tobacco crop, but also which of the grasses would be most suitable for sand veld soil from the point of view of grazing or hay.

As it was thought that the grass crops should receive some form of manurial treatment, the experiment was designed as a split plot arrangement so that four treatments could be superimposed on each grass plot.

The main plots were 36 yards by 10 yards, being split into 4 plots 9 by 10 for sub-treatments. The soil was a light sand having the following average chemical analyses:—

Organic matter (passing through 1 m.m. sieve)	1.02%
Organic matter (retained on 1 m.m. sieve)	0.36%
P_2O_5 (citric soluble)	0.0006%
K_2O	0.004%
P.h.	6.1%
Nitrogen	0.04%
CaO	0.053%

The analysis shows it to be low in phosphate, nitrogen and organic matter. The land used was opened in 1944 and had carried two seasons tobacco

The following grasses were included in the rotation:—

1. Urochloa mosambicensis (Sabi grass).
2. Digitaria milanjiana (Milanje grass).
3. Urochloa bolbodes.
4. Rhodesian Sudan grass (Sorghum arundimaceum).
5. Cenchrus ciliaris (African foxtail).
6. Weed fallow.
7. Giant Rhodes grass (Chloris gayana).

The *Urochloas* and *Digitaria milanjiana* were planted from cuttings on January 17th, 1947, the former being spaced 3 ft. x 18 in. and the latter 3 ft. x 3 ft.

The Sudan grass was seeded at the rate of 20 lbs. per acre on January 11th, 1947.

Giant Rhodes was planted from roots on January 28th, 1947, and spaced 3 ft. x 3 ft.

The *Cenchrus ciliaris* was sown at the rate of 8 lbs. per acre on March 3rd, the late sowing being made owing to the difficulty in obtaining seed.

The dry season was unfavourable for the establishment of grasses either by seed or cuttings, and somewhat patchy stands resulted.

The Sudan grass gave a good germination, while *Digitaria milanjiana*, a creeping grass, rapidly covered the soil. Both the Urochloas gave patchy results in spite of re-filling on March 6th. The germination of *Cenchrus ciliaris* was extremely poor, only a few plants appearing.

As one of the superimposed treatments on each grass, it was decided to give a dressing of compost. This was applied on January 9th, 1947, at the rate of 8 short tons 800 lbs. per acre moist compost.

The compost contained 50% by weight moisture, so the dressing was equivalent to 4 short tons 400 lbs. dry compost.

Field observations on February 4th showed a marked difference between the composted and non-composted plots in the Sudan grass. The germination in the composted plots was very much higher and the growth obviously better.

The Sudan grass was cut on April 16th and fallow plots on April 24th, the grass being weighed from each plot. The following yields of undried grass were obtained (see Table VI).

TABLE VI.

	No Compost.	Compost.
Sudan grass	605 lbs. per acre	1,493 lbs. per acre
Fallow	3,489 lbs. per acre	4,517 lbs. per acre

Samples of the grass from both composted and non-composted plots were analysed to determine whether the compost had altered the chemical composition. The results of this analysis are shown in Table VII.

TABLE VII.

Chemical Analysis of Sudan Grass from Composted and Non-Composted Plots.

Chemical Constituents	Non-Composted.		Composted.	
	Sudan.	Fallow.	Sudan.	Fallow.
Nitrogen	1.64%	0.63%	1.59%	0.71%
Crude protein	10.25%	3.94%	9.94%	4.44%
P_2O_5	0.43%	1.58%	0.41%	1.68%
K_2O	1.35%	0.37%	1.55%	0.43%
CaO	0.98%	0.72%	1.10%	0.69%

Compost has slightly reduced the percentage of crude protein and P_2O_5 in the Sudan grass, but has increased it in the fallow plots. The decrease in the Sudan grass may be due to dilution owing to increased leaf side. The total crude protein per acre has obviously been greatly increased by the application of compost.

The composted plots both of the Sudan and fallow gave an increase in potash and lime.

The other grasses showed little or no response to compost, some, in fact, showing poorer growth. This was the case with *Digitaria milanjiana*, *Urochloa bolbodes* and Giant Rhodes grass.

Notes were taken on July 21st, August 19th, September 13th and October 8th for winter greenness. The two Urochloas and *Digitaria*

milanjiana showed the greatest amount of winter green, followed by Sudan grass and *Cenchrus ciliaris*, the stand in the latter being very poor indeed.

Rhodes grass and fallow showed little in the way of green herbage during the dry season.

NURSERY GRASS PLOTS.

A number of grasses were grown on small plots with a view to selecting useful types for further work. The grasses were:—

1. Digitaria waterval.
2. Star grass No. 8.
3. Purple top buffel panicum maximum.
4. Urochloa mosambicensis.
5. Brachiaria dictyoneura.
6. Kasinga Canal (very similar to Star grass No. 4).
7. Star grass No. 4.
8. Brachiaria nigeropedata.
9. Panicum maximum.
10. Panicum makarikari.
11. Purple top buffel. Panicum maximum.
12. Brachiaria brizantha var. angustifolia.

12a. Thatching grass. Hyparnhenia species.

B. FIELD TRIALS WITH COMPOSTS (by A. A. Moffett).

Composts tests in the past gave variable results, some years showing marked increases in yield, while in other years there was no noticeable effect. Since it was possible that the compost used on the Station was not the best type for tobacco, sufficient compost to carry out tests was obtained from three growers who claimed to have had marked results from the use of compost. A detailed account of the results of these tests has been published in the "Rhodesia Agricultural Journal," so that only an outline is given in this report.

The trial was carried out on a reverted land, that is, a land which had lain under natural fallow for four seasons, having previously carried two crops of tobacco. Five composts were used, two made on the Station and three from outside sources. The composts were:—

(1) Kraal compost: Tobacco stalks, grass, maize stover trampled during the rains by working oxen. Turned twice towards end of rains. No ash or soil added.

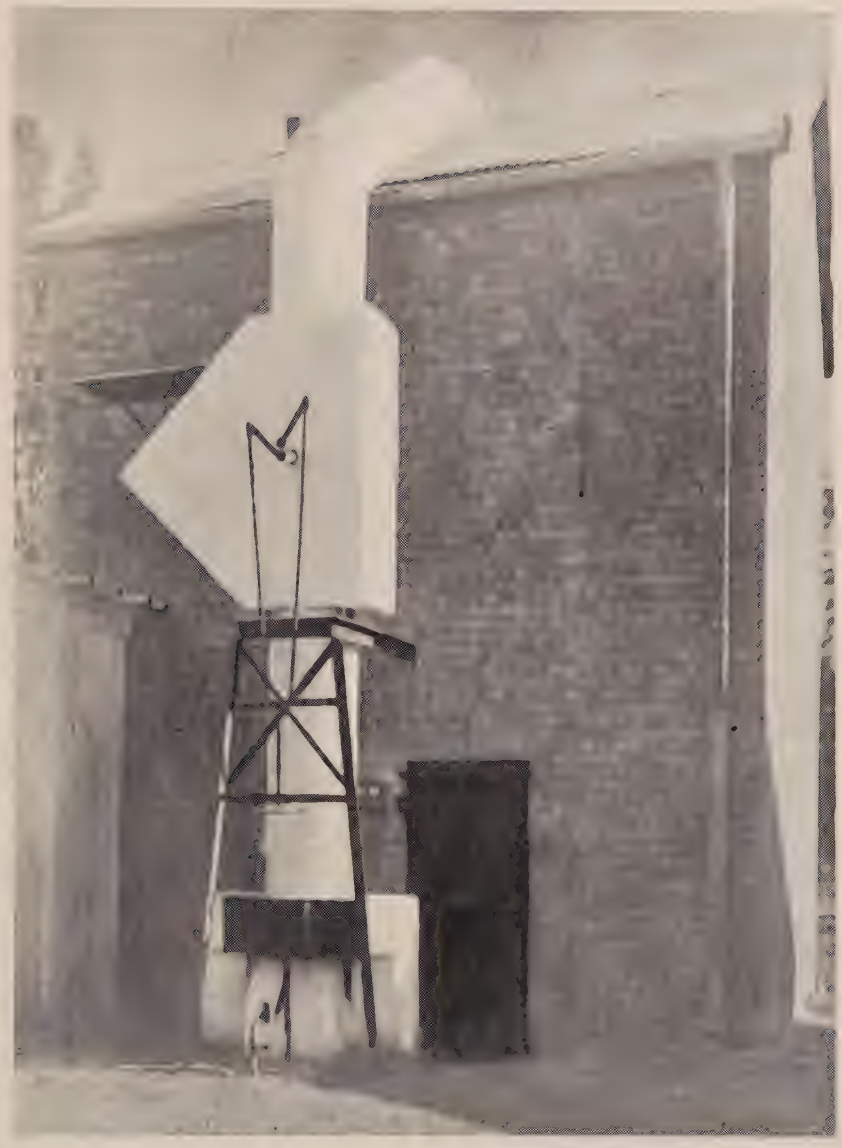
(2) Farm compost: Made from grass and a proportion of tobacco scrap. Trampled by oxen on kraal, commencing May, 1946. Material taken out and watered towards end of August, 1946. Turned 3 times at intervals of about 3 weeks. Considerable amount of ash added.

(4) Farm compost. Prepared from bedding (veld hay) from steers, penned in May. Feeding: whole maize silage bean hay, salt and veld hay. No earth added but a liberal dressing of wood ash was applied.

(6) Farm compost: Made during dry season from veld grass which had been used as bedding for dairy cows, calves and pigs; soil and ash were added in the usual proportions. The heap was turned 4 times, taking about 3 months to reach maturity.

(7) Station compost: Sunn hemp. Made during dry season from sunn hemp stalks only. Stalks were not trampled, but manure was collected and mixed with sunn hemp, together with wood ash. The heap was turned 3 times.

The land chosen for the experiment was a light sandy soil which had been under natural fallow for 4 years. The land was ploughed early



View of Ducting and Heat Exchanger.

in November and the composts were applied on 25th November, being broadcast and dug under with hoes. All composts were applied at the rate of 4 tons dry matter per acre. This gave a dressing of 5 tons per acre moist compost with the lowest moisture content (20 per cent.).

Fertiliser was applied at the rate of 300 lbs. per acre, 10—6—8 mixture, 150 lbs. per acre being applied on 2nd December and 150 lbs. on 23rd January. The land was planted on 27th December with bonanza, the spacing used being 3 ft. x 3 ft.

The following treatments were tested:—

1. Kraal compost (Station) and 300 lbs. per acre 10—6—8 mixture.
2. Farm compost No. 2 and 300 lbs. per acre 10—6—8 mixture.
3. No compost and 300 lbs. per acre 10—6—8 mixture.
4. Farm compost No. 4 and 300 lbs. per acre 10—6—8 mixture.
5. Sunn hemp compost (Station 7). No fertiliser.
6. Farm compost No. 6 and 300 lbs. per acre 10—6—8 mixture.
7. Sunn hemp compost (Station) and 300 lbs. per acre 10—6—8 mixture.

The effect of compost was noticeable at an early stage in the field. Two weeks after planting, the non-fertilised treatment showed no signs of growth, while all other treatments showed a darkening of the leaf and some expansion. All the composted treatments could be distinguished from the non-composted by their more vigorous growth. These differences remained fairly clear-cut right through the growing period, although variations were observed within the composted treatments. The non-fertilised plots showed little sign of growth till 5 weeks after planting, but from that stage on grew fairly well, although always lagging behind the fertilised treatments.

Counts were made of the percentage stand and average leaf number per plant. There was no difference in either leaf number or stand, indicating that compost had not affected them in any way.

The results of the trial on the basis of yield and quality are summarised in Table I.

TABLE I.

Yields, Prices and Values from Compost Trial.

Treatment.	% Stand.	Yield per acre		Price per Pound.		Value per Acre.	
		Lbs.	% of mean.	Pence.	% of mean.	£ s. d.	% of mean.
1—Kraal	92	1,304	115.30	8.61	102.38	46 16 0	117.59
2—Farm No. 2	93	1,110	98.14	8.62	102.50	40 0 0	100.50
3—No compost	93	1,006	88.95	8.26	98.23	34 14 0	87.19
4—Farm No. 4	93	1,273	112.55	8.64	102.73	45 16 0	115.07
5—No fertiliser	91	752	66.50	7.91	94.05	24 16 0	62.31
6—Farm No. 6	94	1,259	111.52	8.34	99.17	43 14 0	109.80
7—Sunn hemp	93	1,212	107.16	8.48	100.83	42 14 0	107.29

"Z" test significant for yield, price and value.

	Yield.	Price.	Value.
Mean of treatments	1,131	8.41	£39 16 0
Standard error	3.37%	1.68%	3.77%
Significant difference 5%	111 lbs.	0.41d.	£4 8 0
Significant difference % of mean	9.81%	4.87%	11.05%

Summary of Significant Differences.

Yield—

All other treatments better than 5.
1, 4, 6 and 7 better than 3.
1, 4, 6 better than 2.

Price—

All other treatments better than 5.

Value—

All other treatments better than 5.
1, 2, 4, 6 and 7 better than 3.
1 and 4 better than 2.

Compost No. 2 was not significantly better than no compost, although almost so, while in value compost No. 1 was almost better than No. 7. The results were analysed again, leaving treatment No. 5 out of the Analysis of Variance, as this treatment was obviously poorer than the others. This increased the accuracy of the experiment, which now showed that all compost and fertiliser treatments (including 2) were better than the fertiliser only treatment in yield, and that in value No. 1 gave a better result than No. 7.

The above results are all given on basic prices. In order to give a clearer picture of the increased returns brought about by the application of compost, the prices and values under prevailing market conditions are given in Table II.

TABLE II.

	Treatment.						
	1	2	3	4	5	6	7
Average price (d.) per lb.	39.00	39.33	37.60	39.86	36.85	38.64	39.60
Cash return per acre (£)	212	182	158	211	116	203	200

Compost on reverted land has had a striking effect in increasing yield and, to a lesser extent, quality. It is also evident that the composts vary considerably amongst themselves in efficacy. An attempt was made to determine by chemical analysis the reasons for the differences between the composts. The results of these analyses are reported fully elsewhere, but two points may be mentioned here. Firstly, unless the carbon/nitrogen ratio of the compost is within certain limits, there is not likely to be any beneficial effect from additional nitrogen, and secondly, that one of the major benefits the crop obtained from compost was an additional supply of available phosphate. Compost may, however, act in many other less obvious ways.

It may be mentioned that the somewhat variable results previously obtained on the Station were due not so much to the type of compost used as to the fact that many of the trials were carried out on second year land. A study of the results of previous seasons showed that the older the land the more marked was the effect of compost.

III.

Combined Cultural and Varietal Trials

By A. A. MOFFETT.

Spacing, Variety, Topping Trial.

This experiment was continued for the third season, using the same treatments and lay-out as previously.

A land consisting of a light sandy soil, which had lain for four years under fallow after two crops of tobacco, was used for the trial. The land was ploughed during October, 1946. On 18th November, 1946, fertiliser (10—6—8) mixture was applied at the rate of 150 lbs. per acre and the land hilled ready for planting. The first planting took place on 22nd November after a good rain, but insect attack and a spell of hot, dry weather so reduced the stand that a complete re-plant was necessary. No further planting rains fell until 27th December, 1946.

A further 150 lbs. per acre, 10—6—8 mixture, was applied on 23rd January, 1947.

The treatments and varieties tested were as follows:—

Spacing.	Topping.	Variety.
3 ft. x 3 ft.	High	Jamaica Wrapper
3 ft. x 2 ft.	Low	White Stem Orinoco
3 ft. 6 in. x 2 ft.		Bonanza
4 ft. x 2 ft.		

High topping consisted of taking the head off just below the flower bud, while low topping was five leaves lower. Topping was, as far as possible, carried out at the same stage—that was, just before the first flower opened.

The results of this experiment are summarised in Tables I, II and III.

TABLE I.

Yields, Prices and Values from Spacing Treatments.

Spacing.	% Stand	Yield per acre		Price per Pound.		Value per Acre.	
		Lbs.	% of mean.	Pence.	% of mean.	£ s. d.	% of mean.
3 ft. x 3 ft.	90	930	92.1	8.24	102.6	31 18 0	94.6
3 ft. x 2 ft.	85	1,049	103.9	7.99	99.5	34 14 0	102.9
3 ft. 6 in. x 2 ft.	83	1,060	104.9	7.94	98.9	35 0 0	103.8
4 ft. x 2 ft.	83	1,003	99.3	7.97	99.2	33 6 0	98.7
"Z" test not significant.							
Mean of treatments		1,010		8.03		£33 14/-	
Standard error		4.91%		1.13%		4.84%	

TABLE II.

Yields, Prices and Values from Varieties.

Variety.	% Stand.	Yield per Acre.		Price per Pound.		Value per Acre.			
		Lbs.	% of mean.	Pence.	% of mean	£	s.	d.	% of mean.
Jamaica Wrapper	81	997	99.0	8.10	100.9	33	12	0	99.7
White Stem Orinoco	83	985	97.8	7.93	98.7	32	8	0	96.1
Bonanza	91	1,049	104.2	8.07	100.5	35	4	0	104.4

"Z" test not significant.

	Yield.	Price.	Value.
Standard error	1.91%	1.08%	2.29%

TABLE III.

Yields, Prices and Values from Topping Treatments.

Treatment.	Yield per Acre.		Price per Pound.		Value per Acre.			
	Lbs.	% of mean.	Pence.	% of mean.	£	s.	d.	% of mean.
High topping	1,029	101.9	8.12	101.1	34	14	0	102.9
Low topping	992	98.2	7.95	99.0	32	15	0	97.1

"Z" test significant for price and value.

	Yield.	Price.	Value.
Standard error	1.51%	0.51%	2.02%

High topping significantly better than low in price and value.

The differences between the spacing treatments were in the same order, but not so marked, as in previous seasons. The lower percentage stand in the closer spacings, and seasonal conditions tended to even out the treatment differences. Being an exceptionally dry season, the plants had to stand up to a long period of drought; it was noticed that in the close spacings the leaf tended to fire more readily, causing a certain amount of loss by premature ripeness. The close spacings produced a slight drop in average price, but the cash values per acre were consider ably increased compared with the standards.

High topping produced a significant increase in price and value, but not in yield. The higher average price with the high topping was a reversal of the two previous seasons' results, and was undoubtedly due to seasonal conditions. There was a tendency for the crop as a whole to run to the heavier medium grades, and this tendency was doubtless accentuated by low topping, with a resultant drop in price.

A number of plants in the high topped treatments were scored for leaf number to determine whether spacing affected the number of leaves and whether there was any difference between the varieties in this respect. The results are summarised in Table IV.

TABLE IV.

Average Leaf Number per Plant in Varieties and Spacing. High Topping.

Variety.	Spacing. 3′ x 3′	3′ x 2′	3′ 6″ x 2′	4′ x 2′	Variety Means.
Jamaica Wrapper	20.6	20.9	20.0	19.9	20.3
White Stem	19.7	20.2	20.6	20.2	20.1
Bonanza	20.9	20.7	20.1	20.3	20.5
Spacing Means	20.4	20.6	20.2	20.1	—

There was no alteration in leaf number with the different spacings and all varieties carried a similar number of leaves.

Results Over Three Seasons. The results of the spacing and topping treatments taken over three seasons are summarised in Tables V to VIII.

Two of the seasons were comparatively dry, but in the third season the rainfall was above average. The seasonal rainfalls were: 1944-45, 26.46 ins.; 1945-46, 40.49 ins.; and 1946-47, 21.53 ins.

TABLE V.

Yields in Lbs. per Acre from Different Spacings over Three-year Period.

Spacing.	1944-45.	1945-46.	1946-47.	Average 3 Years.	% of Standard.
3′ x 3′	970	547	930	816	100.0
3′ x 2′	1,233	717	1,049	1,000	122.5
3′ 6″ x 2′	1,151	731	1,060	981	120.2
4′ x 2′	1,066	608	1,003	892	109.3

TABLE VI.

Average Prices from Spacings over Three-year Period.

Spacing.	1944-45.	1945-46.	1946-47.	Average 3 Years.	% of Standard.
3′ x 3′	9.53	7.58	8.24	8.45	100.0
3′ x 2′	9.04	7.46	7.99	8.15	96.4
3′ 6″ x 2′	9.17	7.47	7.94	8.19	96.9
4′ x 2′	9.25	7.42	7.97	8.21	97.1

TABLE VII.

Value per Acre (£ s. d.) over Three-year Period.

Spacing.	1944-45.	1945-46.	1946-47.	Average 3 Years.	% of Standard.
3′ x 3′	39 9 0	17 6 0	31 18 0	29 4 0	100.0
3′ x 2′	46 8 0	22 3 0	34 14 0	34 8 0	117.8
3′ 6″ x 2′	43 18 0	22 15 0	35 0 0	33 18 0	116.1
4′ x 2′	41 1 0	18 15 0	33 6 0	31 1 0	106.3

TABLE VIII.

Yields and Prices from Toppings over Three-year Period.

	Topping.	1944-45.	1945-46.	1946-47.	Average 3 Years.
Yield (lbs. per acre)	High	1,149	666	1,029	948
	Low	1,060	636	992	896
Price (d. per pound)	High	9.17	7.43	8.12	8.24
	Low	9.33	7.52	7.95	8.26

Discussion. These experiments were designed to test, amongst other factors, whether the three varieties—Jamaica Wrapper, White Stem Orinoco and Bonanza—behaved in a similar manner under different conditions of spacing and topping, or whether some modification would be required to get the best results from any one variety. Over three seasons there was no indication of an inter-action between either spacing and variety, or topping and variety, indicating that spacing and topping had affected all the varieties in a similar manner. From an experimental point of view, the information is important, since it means that the results of spacing tests carried out with one particular variety are, most likely, applicable to all the commonly grown flue-cured types.

Over three seasons' closer spacing increased the yield very considerably compared with the standard 3 ft. x 3 ft. The higher the number of plants per acre the greater was the yield, but the increase in yield was not proportional to the number of plants. The optimum spacing seemed to be in the neighbourhood of 3 ft. 6 ins. x 2 ft. This spacing required 1,038 less plants per acre than 3 ft. x 2 ft., while the yield and value differed by less than 2 per cent. This effects a saving not only in the number of plants required, but also in fertiliser and handling of additional leaf.

The closer spacings have, in each year, been accompanied by a lower average price per pound. The lower average did not, however, appear to be accompanied by any lowering in actual quality, but rather to a rather higher proportion of short leaf in the closer spacings.

There seems little doubt that a closer spacing than the standard 3 ft. x 3 ft. can be adopted to increase the yield without any serious loss of quality: 3 ft. x 2 ft. spacing has been extensively used by many growers who claim very much higher yields than with the standard spacing at the same time producing crops of high quality.

A closer spacing has the advantage of fining down the crop in seasons of rank growth, while in seasons of poor growth the additional plants per acre help to maintain the yield per acre.

IV.

Breeding and Selection

(By A. A. MOFFETT).

The Variety and Strain trials were again continued in small units as it was found that this greatly facilitated field layout and planting. In all, five trials were carried out. Two of these were varietal comparisons, one a test of new varieties derived originally from crosses between good varieties, and two comparisons of the progeny from single plant selections.

Amongst both the new varieties derived from hybrids and single plant selections there were strong indications of promising new varieties and strains. Many of the hybrid varieties showed considerable uniformity of type and other good characteristics such as large leaves carried right to the top of the plant.

These varieties have now reached a stage when they should be tested on a commercial scale when facilities for such tests become available.

All plants bagged for seed were recorded for type, etc., in the field. The leaf was reaped separately from each seed plant and an examination made of the cured leaf for quality, freedom from disease, etc. It has been found in breeding with tobacco that the influence of climate and soil are so great that it is extremely difficult to follow an improved type through from season to season. For example, the progeny of a single plant selection which has shown outstandingly good characteristics, may not come up to the standard of the parent, but nevertheless an examination of environmental factors may lead to the conclusion that the failure was due to outside factors. It follows therefore that the trend of breeding has to be assessed over a number of seasons and that very little comment can be made on an isolated season's results.

All the trials were carried out in the same field and all had identical treatment. The one description of experimental treatment will, therefore, serve for all.

The field was a new land, stumped during the dry season, and ploughed in September, 1946. The initial planting took place on 30th November, after a fairly good rain, but owing to the hot dry weather following was a complete failure.

Replanting took place on 29th December under good weather conditions. White grubs, wireworms and crickets all caused considerable damage, the stand being gradually whittled down until at maturity it was only about 80% over the whole field.

Fertiliser was applied as follows:—

25th November, 1946	150 lbs. per acre	10.6.8 mixture.
22nd January, 1947	150 lbs. per acre	10.6.8 mixture.
6th February, 1947	150 lbs. per acre	10.6.8 mixture.

Growth in all trials was good and, in spite of the somewhat poor stand, good yields of high quality tobacco were obtained.

An examination of the results showed that poor yields were frequently correlated with poor stands. It was established from other experiments that between 70% to 90% stand, the yield was almost directly proportional to the stand. The yields were, therefore, adjusted

for stand, the highest stand in any particular trial being used as a basis for adjustment. When it was considered necessary an analysis of variance was carried out on the adjusted yields. This adjustment may over correct slightly for the higher stands and under correct for the lower, but on the whole is likely to give a truer picture of the comparative varietal yields where big differences between stands occur.

RESULTS OF EXPERIMENTS.

Trial A. This was similar to A of the previous season except that Virginia Bright was omitted. This variety, while giving high yields, produced a woody type of leaf which in spite of several years' selection, showed little improvement.

The varieties were:—

A1 Jamaica Wrapper, A2 Willow Leaf, A3 White Stem Orinoco, A4 Yellow Mammoth, A5 Bonanza, A6 Gold Dollar.

The results are summarised in Table I.

TABLE I.

Yields, Prices and Values in Variety Trial A.

Variety.	% Stand.	Yield per acre.			Price per pound.		Value per acre.		
		Adjusted to 89% Stand.	Lbs.	% of Mean.	Pence.	% of Mean.	£ s. d.		% of Mean.
A 1	82	1,008	929	98.1	9.12	99.1	35	8 0	97.5
A 2	88	1,051	1,039	109.7	9.06	98.5	39	5 0	108.2
A 3	89	955	955	100.9	8.87	96.4	35	4 0	97.0
A 4	84	949	895	94.5	9.66	105.0	36	2 0	99.5
A 5	84	1,029	971	102.5	9.20	100.0	37	4 0	102.5
A 6	84	947	894	94.4	9.29	101.0	34	12 0	95.3

"A" test significant for price.

	Yield.	Price.	Value.
Mean of varieties	947 lbs.	9.20d.	£36 6 0
Standard Error	7.73%	1.50%	8.20%
Significant Diff. 5%	Nil	0.40d.	Nil
Sig. Diff. % of Mean ...	Nil	4.3%	Nil

Summary of Significant Differences.

Price: No. 4 better than 1, 2, 3 and 5.
No. 6 better than 3.

The error of the experiment due to soil variation was large, and although the difference between varietal yields was high the differences did not reach the level of significance even when the yields were adjusted to stand. A4, Yellow Mammoth, gave an outstandingly high price. The leaf from this variety was very bright, of clear colour and good quality. White Skin Orinoco gave an average price considerably below most of the other varieties. An examination of the leaf from this variety in the grading shed showed, that while the oilyness and body were good, there was a tendency to sponge and less clear bright leaf was produced than in the other varieties. The quality in all cases

was good; Willow Leaf and Yellow Mammoth produced a rather thinner leaf than the others.

Variety Trial B. This consisted, as in the previous season, of a trial of a number of varieties, mostly from Canada, which have been grown and selected for a number of years. The number of varieties was reduced from twelve to eight, those which have proved to be unsuitable for local conditions being dropped.

The following were the varieties tested and the original source from which they were derived.

B1 Bonanza, Canada, 68.
B3 Bonanza Station Strain.
B5 Gold Dollar, Canada, 69.
B7 Duquesne, Canada, 72.
B2 Bonanza, Canada, 47.
B4 Gold Dollar, Canada, 82.
B6 Yellow Mammoth, Canada, 58.
B8 Jamaica Wrapper, Local.

The yields, prices and values are summarised in Table II.

TABLE II.

Yields, Prices and Values in Variety Trial B.

Variety.	% Stand.	Yield per acre.			Price per pound.		Value per acre.		
		Adjusted to 83% Stand.	Lbs.	% of Mean.	Pence.	% of Mean.	£ s. d.		% of Mean.
B 1	83	897	897	100.4	9.43	102.8	35	6 0	103.3
B 2	82	971	959	107.4	9.63	105.0	38	8 0	112.5
B 3	74	953	850	95.2	9.28	101.2	32	18 0	96.3
B 4	82	1,017	1,005	112.5	9.21	100.4	38	12 0	113.0
B 5	82	809	799	89.5	9.10	99.2	30	8 0	88.9
B 6	81	980	956	107.0	9.10	99.2	36	6 0	106.2
B 7	69	882	733	82.1	8.96	97.7	27	6 0	79.9
B 8	80	976	941	105.4	8.69	94.8	34	2 0	99.8

"Z" test significant for yield, price and value.

	Yield.	Price.	Value.
Mean of varieties	893 lbs.	9.17d.	£34 3 0
Standard Error	4.81%	1.74%	6.90%
Significant Diff. 5%	124 lbs.	0.46d.	£5 8 0
Sig. Diff. % of Mean... ...	13.8%	5.00%	15.9%

Summary of Significant Differences.

Yield: No. 4 better than 3, 5 and 7.
Nos. 2, 6 and 8 better than 5 and 7.
No. 1 better than 7.

Price: No. 2 better than 5, 6, 7 and 8.
No. 1 better than 8.

Value: Nos. 4 and 2 better than 3, 5 and 7.
No. 6 better than 5 and 7.
No. 1 better than 7.

On the observed figures No. 4 Gold Dollar Canada 89 outyielded the Station Bonanza (No. 3), Gold Dollar No. 69 and Duquesne No. 7. In Nos. 3 and 5 the stand was much lower than in No. 4. A lower stand does not necessarily indicate a varietal weakness; in fact, the reverse may be the case, since the stand is very frequently dependant upon the seedlings planted out. A vigorous variety with a high seed germination may produce more crowded seed beds than a more weakly variety. This tends to produce thin weakly seedlings ill adapted to stand up to the vigorous conditions in the field with a resultant low stand.

Statistical analysis of the stand counts showed that varieties Nos. 1, 2, 4, 5 and 6 all had significantly better stands than 7 or 3, and No. 8 was almost significantly better.

The yields were accordingly adjusted to the highest percentage stand, i.e., 83% and an analysis of variance worked out on these figures. On this basis the difference did not reach the level of significance, but the higher yielding varieties were almost significantly better than Nos. 5 and 7. Taken in conjunction with previous years results this almost certainly indicates that Gold Dollar 69 and Duquesne are lacking in vigour compared with the other varieties. The results on the basis of price were not very consistent with the previous years.

Variety Trial C. This consisted of a trial of some of the better varieties derived originally from inter-varietal hybrids.

The following were tested:—

C1 Gold Dollar x Jamaica Wrapper C1/46.
C2 Bonanza, Station Strain.
C3 Bonanza x Jamaica Wrapper 5/46.
C4 ,, ,, ,, ,, 6/46.
C5 ,, ,, ,, ,, 7/46.
C6 ,, ,, ,, ,, 10/46.
C7 ,, ,, ,, ,, 8/46.

The soil was uneven on the side of the field on which this trial was situated. Some patches proved to be rather heavy (due to termite activity) and the tobacco tended to be rather rank. This accounted for the rather lower average prices compared with the other trials. The results are summarised in Table III.

TABLE III.

Yields, Prices and Values from trial C.

Variety.	% Stand.	Yield per acre.			Price per pound.		Value per acre.		
		Adjusted to 88% Stand.	Lbs.	% of Mean.	Pence.	% of Mean.	£ s. d.		% of Mean.
C 1	85	1,020	985	105.2	8.61	96.5	35	5 0	101.3
C 2	88	1,176	1,176	125.6	9.01	101.0	44	1 0	126.6
C 3	76	1,008	871	93.0	8.90	99.6	32	8 0	93.1
C 4	80	1,049	954	101.9	8.90	99.8	35	8 0	101.9
C 5	78	1,055	935	99.9	9.40	105.4	36	13 0	105.3
C 6	76	929	802	85.7	8 81	98.7	29	9 0	84.7
C 7	71	1,029	830	88.7	8.77	98.3	30	7 0	87.3

"Z" test significant for yield, prices and value.

	Yield.	Price.	Value.
Mean of varieties	936 lbs.	8.92d.	£234 16 0
Standard Error...	4.81%	1.69%	4.48%
Significant Diff. 5%	130 lbs.	0.43d.	£5 5 0
Sig. Diff. % of Mean... ...	13.9%	5.23%	15.1%

Summary of Significant Differences.

Yield: 2 better than all other varieties.
1 better than 6 and 7.
Price: 5 better than 1, 3, 4, 6 and 7.
Value: 2 better than all other varieties.
5 better than 6 and 7.

When the yields were adjusted to an 88% stand the statistical analysis showed no significant differences between the varieties in yield. The yield differences were, therefore, largely a matter of differences in stand. No. 5 which was derived from C7 of 1946 again gave a price above average but no differences showed between the other varieties.

Variety Trial D. When examining leaf from single plant selections made in the 1945-46 crop a number of plants were observed which seemed to produce leaf of outstanding quality. These plants occurred over a number of varieties. Seed from these single plants was taken and the progeny compared in a trial. The following were the single plant selections:—

1. Bonanza A. B6. 1946.
2. Gold Dollar A. A7. 1946.
3. Bonanza Can B.E1. 1. 1946.
4. Bonanza Can B.F.2. 4. 1946.
5. White Mammoth Can. B.E4. 3. 1946.
6. Duquesne B. F9. 1. 1946.
7. Yellow Mammoth B.C3. 5. 1946.
8. Bonanza Station. C.F4. 4. 1946.
9. Bonanza Station C.A4. 2. 1946.

The results of this trial are summarised in Table IV.

TABLE IV.

Yields, Prices and Values from trial D.

Variety.	% Stand.	Yield per acre.			Price per pound.		Value per acre.		
		Adjusted to 90% Stand.	Lbs.	% of Mean.	Pence.	% of Mean.	£ s. d.		% of Mean.
D 1	86	1,000	956	99.9	8.98	97.1	35	19 0	97.2
D 2	84	882	823	85.9	9.39	101.5	29	9 0	79.7
D 3	85	1,041	983	102.4	8.78	95.0	38	17 0	105.4
D 4	86	955	913	95.2	9.56	103.4	36	9 0	98.6
D 5	87	1,048	1,013	105.5	9.11	98.5	38	11 0	104.3
D 6	83	1,002	924	96.5	9.10	98.4	35	4 0	95.3
D 7	86	1,045	999	104.3	9.19	99.3	38	6 0	103.6
D 8	83	1,059	977	101.4	9.55	103.2	38	10 0	104.2
D 9	90	1,036	1,036	108.2	9.58	103.6	41	7 0	111.9

"Z" test significant for price and value.

	Yield.	Price.	Value.
Mean of varieties	958 lbs.	9.25d.	£36 19 0
Standard Error...	5.33%	1.44%	4.12%
Significant Diff. 5%...	Nil	0.38d.	£5 12 0
Sig. Diff. % of Mean... ...	Nil	4.14%	15.15%

Summary of Significant Differences.

Price: No. 9 better than 1, 3, 5, 6 and 7.
4 and 8 better than 1, 3, 5 and 6.
2 better than 1 and 3.
7 better than 3.

Value: No. 9 better than 2 and 6.
Nos. 1, 3, 4, 5, 6 and 8 better than 2.

A statistical analysis of the yields adjusted to a 90% stand showed no significant differences. The error of the experiment was, however, high and significant differences did not show up below about 15%.

It is noteworthy that No. 2, a selection from Gold Dollar, has given a lower yield than any of the other selections. Gold Dollar has been shown, over a number of years, to be less vigorous than the majority of varieties, so the lower yield probably represents a real difference. Three of the selections gave prices well above the average (Nos. 4, 8, 9) but further progeny tests must be made to determine whether this improvement is heritable or not.

Trial E. Amongst the single plant selections made in the previous seasons in new varieties derived from inter-varietal hybrids, a number showed unusually high quality in the cured leaf. Seed from these plants was grown separately to determine by progeny trials whether the improvement was heritable or not. The following were tested:—

E 1. Jamaica Wrapper x Gold Dollar 1/46 C.F1.1.
E 2. Jamaica Wrapper x Gold Dollar 2/46 C.A2.3.
E 3. Bonanza x Jamaica Wrapper 5/46 C.A.5.1.
E 4. Bonanza x Jamaica Wrapper 5/46 C.A5.3.
E 5. Bonanza x Jamaica Wrapper 6/46 C.E6.2.
E 6. Bonanza x Jamaica Wrapper 7/46 C.E7.2.
E 7. Bonanza x Jamaica Wrapper 10/46 C.A10.1.
E 8. Bonanza x Jamaica Wrapper 10/46 C.E10.3.
E 9. Willow Leaf Jamaica Wrapper 9/46 C.E9.1.

The type of leaf and habit of the plant in the land were very different in these single plant selections. All gave good yields of high quality tobacco except for E.2 which was rather low in yield. The results are tabulated in Table V.

TABLE V.

Yields, Prices and Values from single plant selections from inter-varietal hybrids.

Variety.	% Stand.	Yield per acre. Adjusted to 90% Stand.	Yield per acre. Lbs.	Yield per acre. % of Mean.	Price per acre. Pence.	Price per acre. % of Mean.	Value per acre. £ s. d.	Value per acre. % of Mean.
E 1	86	1,096	1,047	103.3	9.28	99.3	40 9 0	102.5
E 2	76	984	831	82.0	9.18	98.2	31 12 0	80.1
E 3	83	1,067	984	97.1	9.42	100.8	38 12 0	97.9
E 4	82	1,190	1,084	107.0	9.38	100.3	42 4 0	107.0
E 5	86	1,068	1,021	100.7	9.45	101.2	40 6 0	102.1
E 6	80	1,105	983	97.1	9.39	100.5	38 10 0	97.6
E 7	86	1,099	1,050	103.6	9.04	96.7	39 12 0	100.4
E 8	90	1,117	1,117	110.2	9.38	100.3	43 12 0	110.5
E 9	83	1,086	1,002	98.9	9.58	102.5	40 2 0	101.6

"Z" test significant for yield, prices and value.

	Yield.	Price.	Value.
Mean of varieties	1,013 lbs.	9.34d.	£39 9 0
Standard Error...	5.01%	0.97%	5.44%
Significant Diff. 5%...	145 lbs.	0.26d.	£6 3 0
Sig. Diff. % of Mean... ...	14.33%	2.78%	15.55%

Summary of Significant Differences.

Yield: All varieties better than 2.
Price: No. 9 better than 1, 2 or 7.
No. 5 better than 2 and 7.
Nos. 3, 4, 6 and 8 better than 7.
Value: All better than 2.

The yields adjusted to a 90% stand are given in column three of the table.

The derivatives from Bonanza and Jamaica Wrapper have, on the whole, given a better average price than the other hybrids. While some of these lines offer to be promising varieties it is difficult to assess their value on an experimental scale. Until tests (at present impossible) on a commercial scale can be made with these new varieties little can be said about their true worth.

V.

Soil Insect Pests

(By A. A. MOFFETT).

A. GAMMEXANE TRIALS (gamma isomer of benzene hexachloride).

The tests with Gammexane for the control of various species of white grubs (*Anomalo*, *Schizonycha*, *Adoretus*) and false wireworms (*Psamnodes similis*) were continued. Mitchell's experiments ("Rhodesia Agricultural Journal," 1946) showed that Gammexane significantly reduced the population of white grubs, and that the maximum kill was not produced until six or seven weeks after application. Even the highest application did not give a complete kill and, since results were based on grub counts it was not certain whether the proportion of grubs destroyed would materially affect the stand of tobacco.

To cover these points, two identical experiments were laid out. One of these "A" was not planted to tobacco, but counts of the grub and wireworm population were made, while the other "B" was planted to tobacco and an analysis made of the loss of stand due to various causes, yield and quality of the cured leaf were also noted.

Since the treatments included in the two experiments, methods of application of Gammexane, etc., were the same up to the time of planting, the one description of the experimental details will serve for both. The land chosen for the test was a light grey sand which had carried a crop of tobacco the previous season. White grubs and wireworms have always been particularly troublesome on this type of soil.

Experimental Details. The experiments were originally planned to compare dusts containing seven different percentages of Gammexane and a control, but subsequently a request was received from African Explosives and Chemical Industries Ltd. to test two types of Gammexane dust over each of the seven percentages. As the field plots had already been demarcated, a modified design had to be used. The original design was a randomised block arrangement, with six replications. In the modified design the treated plots were split, half being treated with type 1 Gammexane and half with type 2. The original control plots were left, but were omitted from the analysis of variance, the remaining treatments being analysed as an ordinary split plot arrangement.

The treatments in experiments A and B are given in Table I.

TABLE I.

Percentages of Gammexane used. Treatments 1-7 type 1, 9-15 type 2.

Treatment 1 and 9	0.50% Gammexane at 300 lbs. per acre.
2 ,, 10	0.40% Gammexane at 300 lbs. per acre.
3 ,, 11	0.33% Gammexane at 300 lbs. per acre.
4 ,, 12	0.25% Gammexane at 300 lbs. per acre.
5 ,, 13	0.17% Gammexane at 300 lbs. per acre.
6 ,, 14	0.08% Gammexane at 300 lbs. per acre.
7 ,, 15	0.04% Gammexane at 300 lbs. per acre.
8 ,, 16	No Gammexane.

The main plots were 10 x 14 yards and the sub plots 10 x 7 yards. Sub-plots were demarcated on one side by a six foot path, and on the other by a "neutral" row of plants which received no treatment.

Gammexane was applied to both experiments on 20th November, 1946. The amount required for each sub-plot was weighed and, to ensure even distribution, further sub-divided by measuring the amount to be broadcast per square yard with a fertiliser cup. After broadcasting, the Gammexane was dug under to a depth of 3 to 4 inches. From this stage on the two experiments received different treatment.

Experiment A. This experiment was not planted to tobacco, but counts of white grubs and wireworms were made to determine the kill. Sampling was commenced on January 8th, 1947, seven weeks after the application of Gammexane. Seven separate yard squares, or 10% of the total area, were taken at random in each sub-plot; and the soil dug out and sifted. The numbers of white grubs and wireworms were recorded, but no attempt was made to divide the white grubs into their various species. The results of the sampling are given in Table II.

TABLE II.

Numbers of White Grubs and Wireworms in 42 square yard samples.

		White Grubs.		Wireworms.	
Percentage Gammexane.	Type of Gammexane.	Number of grubs	Total Types 1 and 2.	Number of Wireworms.	Total Types 1 and 2.
0.50	1	23	46	8	9
	2	23		1	
0.40	1	20	37	10	12
	2	17		2	
0.33	1	69	89	7	9
	2	20		2	
0.25	1	28	67	8	13
	2	39		5	
0.17	1	40	71	8	24
	2	31		16	
0.08	1	32	67	21	36
	2	35		15	
0.04	1	87	130	43	57
	2	43		14	
0.00	1	179	290	43	90
	2	111		47	
Total Type 1			299		105
Total Type 2			208		55

Significant Differences.

White Grubs. No significant difference between the percentages of Gammexane.

Wireworms: No significant differences between 0.50% to 0.25%.
0.50% and 0.33% better than 0.17%.
0.5%-0.25% better than .0.08%.
0.5%-0.08% better than 0.04%.
Type 2 better than type 1.

Since the majority of the figures recorded were small the numbers were transformed to $\sqrt{(X + \frac{1}{2})}$ for statistical analysis. In reconversion to whole numbers the means are somewhat lower than the actual recorded figures. For the purposes of this report the recorded figures are given in Table II. as only thus can comparison with the controls be shown.

For both white grubs and wireworms there was a significant difference between the two types of Gammexane dust, type 2 being better than type 1.

Although there was some increase in the number of white grubs with the decreasing percentages of Gammexane the differences did not approach the level of significance.

The number of wireworms remained constant between the 0.50% and 0.25% percentages of Gammexane, but with the lower percentages rose steadily.

The controls had a considerably higher number of both white grubs and wireworms than even the lowest percentage of Gammexane.

Experiment B. This experiment was fertilised and planted to tobacco in the normal way.

Fertiliser was applied at the rate of 150 lbs. per acre on 21st December, 1946, and the land hilled ready for planting. Planting took place on 30th December under fairly good conditions. A further application of 150 lbs. per acre of fertiliser was applied on 21st January, 1947.

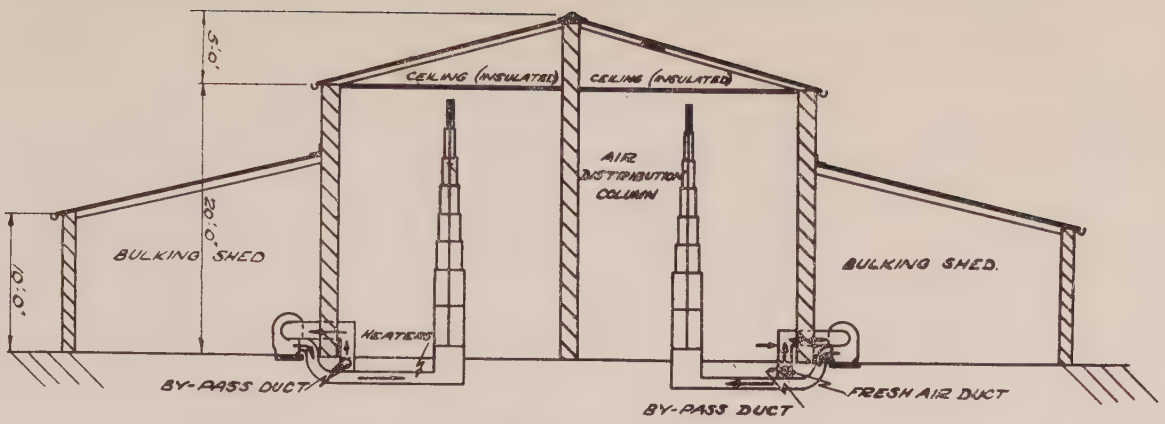
After the initial planting no further refilling was done. Three weeks after planting an analysis was made of the various causes reducing the stand. The results of this analysis are given in Table III.

The loss of stand due to white grubs was low throughout all Gammexane treatments. There was no significant difference between the highest and lowest percentage, and all treatments were obviously better than the controls.

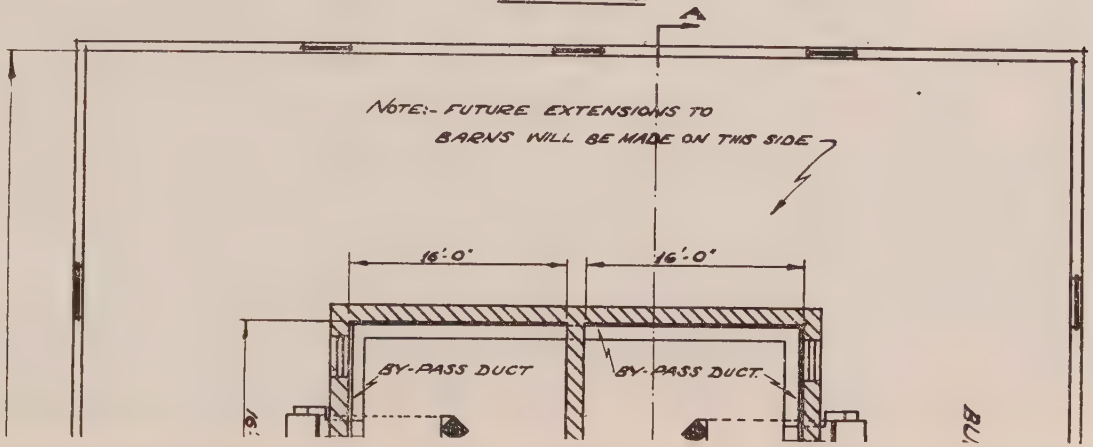
The loss of stand due to wireworms was low between the 0.50% and 0.25% percentages of Gammexane, but showed a tendency to increase as the percentage dropped below 0.17. A statistical analysis of the results showed that the percentages between 0.50% and 0.17% inclusive were all better than 0.08% and 0.04%. All percentages were, however, very much better than the controls.

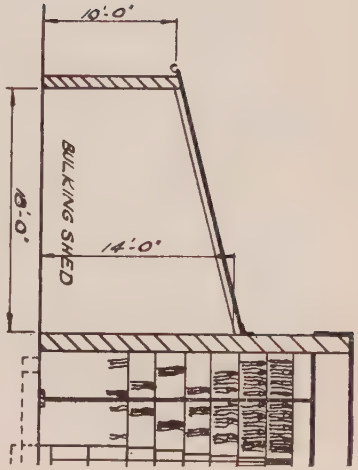
The loss of stand under column 5, unidentified insects, was obviously due to either white grubs or wireworms, but as the insects had either moved off or been destroyed it was not possible to determine which. The loss was more variable than the losses due to white grubs and wireworms taken individually. There was some tendency for the loss to increase as the percentages of Gammexane decreased, but the increases did not reach the level of significance.

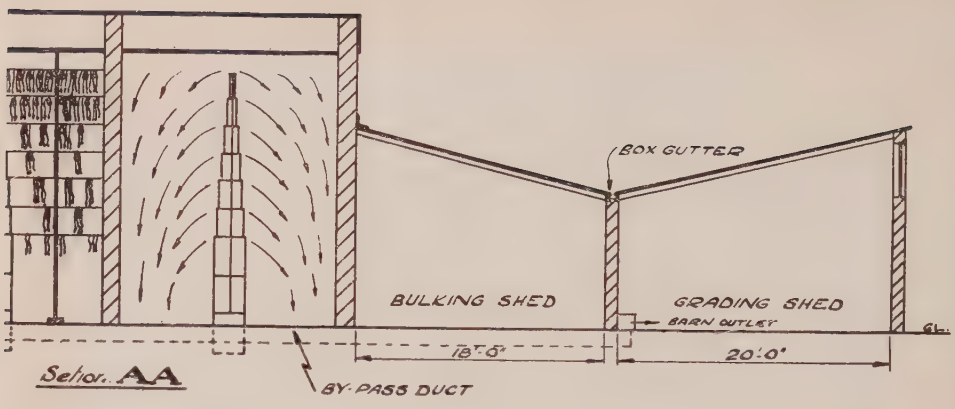
Column 7 shows the percentage loss of stand due to a combination of white grubs, wireworms and unidentified causes. The higher percentages of Gammexane have given very good protection, the loss of stand being less than 1% compared with over 10% in the controls.


5'-0"
CEILING (INSULATED)
CEILING (INSULATED)
AIR DISTRIBUTION COLUMN
20'-0"
10'-0"
BULKING SHED
BULKING SHED.
HEATERS
BY-PASS DUCT
BY-PASS DUCT
FRESH AIR DUCT

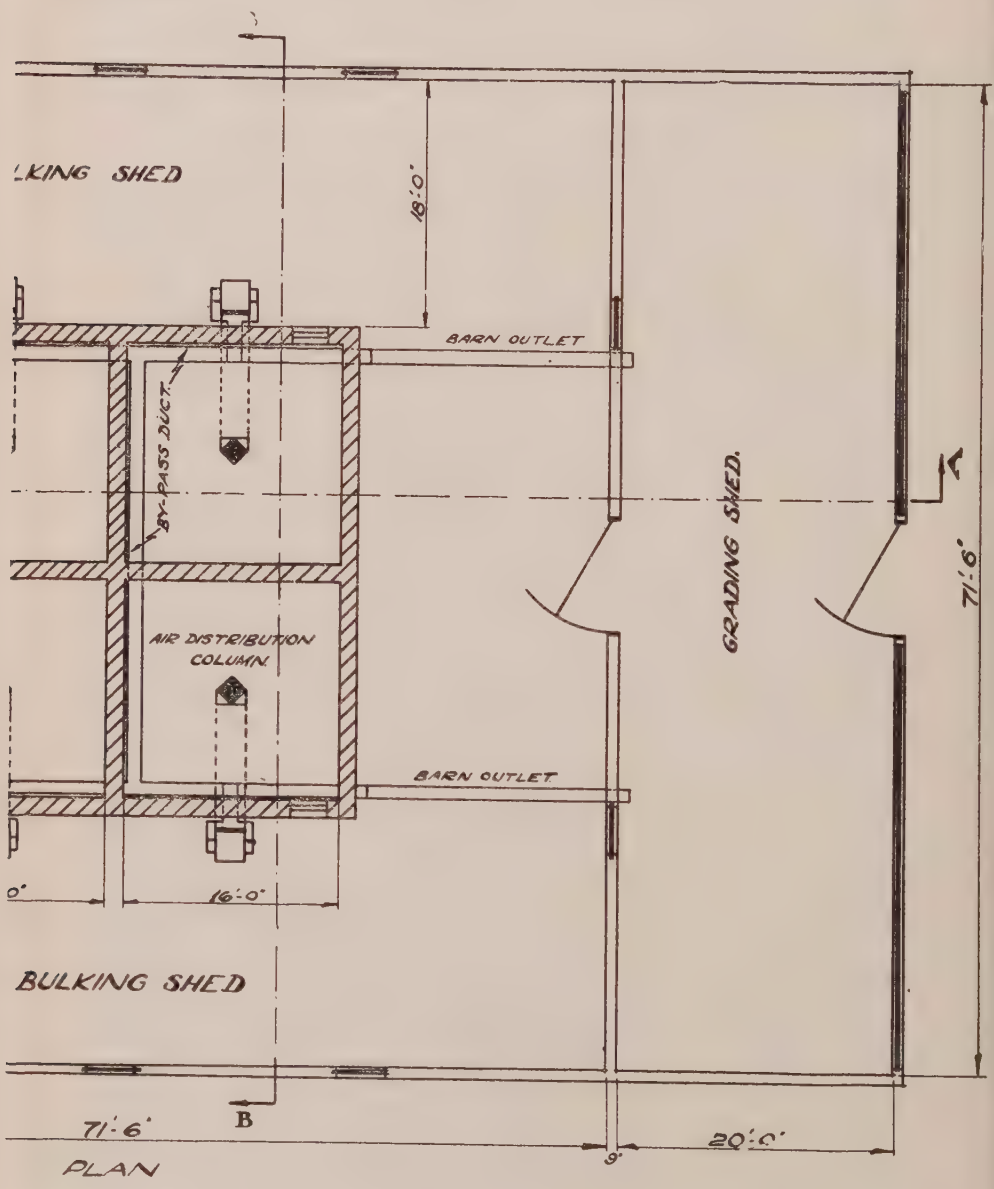
Section B.-B.


NOTE:- FUTURE EXTENSIONS TO BARNS WILL BE MADE ON THIS SIDE
16'-0"
16'-0"
BY-PASS DUCT
BY-PASS DUCT.


10'-0"
BULKING SHED
13'-0"
14'-0"



Sehor. AA



PLAN

OPOSED LAYOUT OF
OUR BARN UNIT

Fig. 1

TABLE III.

Analysis of Loss of Stand three weeks after planting.

NUMBERS.

1	2	3	4	5	6	7	8	9	10	11	12	13
Percentage Gammexane.	Type of dust.	Loss due to white grubs.	Loss due to wireworms.	Loss due to insects not identified.	Total Columns 3-5.	%Loss due to 3, 4 and 5.	Loss due to crickets.	%Loss due to crickets.	Loss due to bad planting, etc.	%Loss due to 10.	%Stand 3 weeks after planting.	%Loss of stand between 3 weeks and maturity.
0.50	1	1	0	3	4	0.95	25	5.95	8	1.90	91.2	1.1
	2	2	0	0	2	0.48	15	3.57	7	1.67	94.3	1.8
0.40	1	0	0	1	1	0.24	11	2.62	11	2.62	94.5	4.3
	2	0	2	1	3	0.71	14	3.33	8	1.90	94.0	3.6
0.33	1	2	2	5	9	2.14	23	5.48	11	2.62	89.8	3.4
	2	1	1	5	7	1.67	27	6.43	10	2.38	89.5	4.1
0.25	1	0	2	3	5	1.19	9	2.14	7	1.67	95.0	2.5
	2	1	1	1	3	0.71	12	2.86	7	1.67	94.8	2.1
0.17	1	0	5	6	11	2.62	26	6.19	12	2.86	88.3	6.2
	2	0	0	8	8	1.90	23	5.48	12	2.86	89.8	5.9
0.08	1	2	5	0	7	1.67	24	5.71	12	2.86	89.8	4.6
	2	1	5	3	9	2.14	18	4.28	6	1.43	92.1	5.2
0.04	1	2	11	11	24	5.71	15	3.57	6	1.43	89.3	3.9
	2	3	5	7	15	3.57	15	3.57	16	3.81	89.0	5.9
0.00	1	8	22	20	50	11.90	24	5.71	17	4.05	78.3	10.2
	2	14	15	11	40	9.52	28	6.67	11	2.62	81.2	12.9

The loss of stand due to crickets was heavier than that due to any other single cause. Crickets, in spite of their burrowing habits, did not appear to be harmed in any way by the Gammexane and on digging out the holes no more than the normal number of dead crickets were found. An examination of the figures of losses due to crickets shows that there is a random distribution of damage and that there was no difference between the treatments and the controls. This applies also to losses due to bad planting, weakly plants, sun scorch, etc.

The stand three weeks after planting was considerably higher than at maturity (Table III. cols. 12 and 13). The loss in the intervening period was attributed to some extent to crickets. From three weeks onward every effort was made to eliminate crickets, but considerable damage was caused before they were brought under control. It will be noted, however, that the loss between three weeks and maturity was very much greater in the controls than in the Gammexane treatments, indicating that white grubs and wireworms were still causing damage and that the Gammexane was still affording a considerable measure of protection.

Results at Maturity. The stand at maturity, yield of cured leaf and average prices are given in Table IV.

TABLE IV.

Stands at Maturity, Yields and Average Prices.

Percentage Gammexane.	Type of Dust.	% Stand at Maturity.	Yield lbs. per acre.	Average Price pence per lb.
0.50	1	90.1	847	8.97
	2	92.5	813	8.54
0.40	1	90.2	858	8.53
	2	90.4	706	8.64
0.33	1	86.4	848	8.58
	2	85.4	760	8.52
0.25	1	92.5	839	8.77
	2	92.7	878	8.62
0.17	1	82.1	817	8.76
	2	83.9	789	8.59
0.08	1	85.2	731	8.71
	2	86.9	791	8.84
0.04	1	85.4	764	8.40
	2	83.1	788	8.55
0	1	68.1	659	8.63
	2	68.3	678	8.66
Totals Type 1		87.4	815	8.67
Totals Type 2		87.8	789	8.61

All the treated plots had a considerably higher percentage stand than the controls. There were some indications of a drop in stand with the decreasing Gammexane dressing, but this trend was not consistent and was not significant.

The yield of all treated plots was very considerably higher than the controls, but here again, variations between treatments were not great and there was no significant difference between the various percentages of Gammexane.

The average prices were very similar over all treatments and the controls, the Gammexane quite obviously having no effect whatsoever on quality.

Discussion. All the Gammexane treatments have given good control of white grubs and wireworms, the 0.04% even being much better than the non treated plots. There is, however, a falling off in its efficacy against wireworms when the concentrations are lower than 0.25%, indicating that the wireworms are more resistant than white grubs. One interesting point is the fact that while type 2 Gammexane dust gave significantly better kill of grubs and wireworms in experiment A, this difference did not show up as might have been expected in the stand counts in experiment B.

Dunn, Henderson and Stapley (1946) working on wireworms in wheat found that Gammexane quickly renders the wireworms incapable of attacking the crop, but that any killing action appears to be considerably delayed. Since type 1 had not given as good a kill as type 2, but there was little difference in the stand counts between the two types, it would appear that type 1 had incapacitated but not killed

the grubs and wireworms. If this was the case, then counts of grubs killed are not necessarily a criterion of the efficacy of the treatment. It is also possible that if Gammexane renders grubs and wireworms incapable of attack some considerable time before killing, it may be feasible to apply Gammexane considerably nearer to planting time than Mitchell's results led him to conclude. From a practical point of view this might permit applying Gammexane mixed with the fertiliser thus reducing field operations.

There seems to be little doubt that Gammexane can give a high degree of protection against both white grubs and wireworms. The problem now remains to determine the best method of application and how to reduce the costs. Tobacco plants require protection for about five weeks after planting. If Gammexane has a fairly rapid stunning effect, local applications around the plant just before planting, instead of treating the whole area, should be effective. The area of land treated could be greatly reduced by local application and the costs cut accordingly. Tests have been planned to determine the relative efficiency of local application and broadcasting and to determine whether any residual effects of the treatment are apparent in the following season.

Acknowledgements. The Gammexane dusts, ready mixed, were supplied by Messrs. African Explosives and Chemical Industries, Ltd.

The field sampling for white grubs and wireworms was carried out by Messrs. R. Turner-Smith, J. Skaife and T. Croeser.

Reference: Dunn, E., Henderson, V. E., and Stapley, J. H. (1946), Nature 158.

B. D.D.T. TESTS.

The tests with D.D.T. for the control of soil insects were planned on similar lines to those with Gammexane. Two identical experiments were laid down, one being sampled for the insect population, while the other was planted to tobacco and subsequently analysed for yield, loss of stand, etc. As little was known about the rates of application the highest levels were based on tests in England for the control of leather jackets and wireworms (Dawson & Escritt 1946, Golightly 1946).

The treatments were as follows:—

1. 50 lbs. per acre 5% D.D.T. (technical)
2. 100 lbs. per acre 5% D.D.T. (technical)
3. 150 lbs. per acre 5% D.D.T. (technical)
4. No D.D.T.

Experimental Details. The D.D.T. was applied to both experiments on 21st November, 1946. The required amount was broadcast over each plot and then dug under with hoes to a depth of about four inches. The experiment which was to be planted to tobacco was fertilised in the normal manner, 300 lbs. per acre being applied in two applications. A randomised block layout with four replications was used in each case. Plots were 9 x 11 square yards. On the 15th January, 1947, seven samples of one square yard each were taken in each plot and counts made of the white grubs and wireworms. The results of these counts are given in Table V.

TABLE V.

White Grubs and Wireworms in 28 square yard samples.

Treatment.	White Grubs.	Wireworms.
50 lbs. per acre 5% D.D.T. ...	103	26
100 lbs. per acre 5% D.D.T. ...	121	44
150 lbs. per acre 5% D.D.T. ...	65	44
No D.D.T.	197	50

The analysis of variance was worked out on $\sqrt{x}$ transformations for both white grubs and wireworms.

All the D.D.T. treatments had significantly less white grubs than the control, but no significant reduction in the number of wireworms occurred.

In the second experiment the loss of stand due to various causes was analysed three weeks after planting. The results of the analysis are given in Table VI.

TABLE VI.

Loss of Stand due to various causes in D.D.T. Experiment.

	Loss of Stand due to							
D.D.T. Treatment.	White Grubs	Wireworms.	Unidentified Insects.	Causes unknown.	Crickets.	Total.	% Stand at 3 weeks.	Yield per acre—lbs.
50 lbs. per acre	9	22	28	37	16	112	71.7	656
100 lbs. per acre	3	13	4	26	14	60	84.8	725
150 lbs. per acre	2	9	11	17	12	51	87.1	913
None	17	33	8	35	31	124	68.7	520

The loss of stand due to white grubs was significantly higher in the control than in treatments 2 and 3, while the loss of stand in 1 was almost significantly higher than 3.

There were no significant differences in the loss of stand due to wireworms, but the differences approached very closely to significance. There was probably a real reduction in the loss of stand with treatment 3. It was noticed in two or three cases wireworms which had destroyed a plant were moribund. D.D.T. is evidently very slow in its effect on wireworms.

When a plant had completely disappeared or when its loss could be attributed to no particular cause it was listed under "causes unknown." In many cases the loss was due to faulty planting, sun scorch, etc., but the lower figure under treatment 3 seems to indicate that insects were partially responsible for losses under this heading and that D.D.T. has controlled them to some extent.

There was some indication of a reduction in damage due to crickets in the higher D.D.T. treatments, but as these insects are very mobile a more detailed experiment would be required to test whether this was the case or not.

As would be expected from the differences in percentage stand large differences in yield occurred. The error of the experiment was very high for yield data, the standard error being 10.37% of the mean. Treatment 3 gave significantly higher yield than Nos. 4 or 1, and the difference was almost significantly better than 2.

There were no indications of any effect of D.D.T. on the quality of the tobacco produced.

D.D.T. has had some effect in controlling white grubs and possibly to a lesser extent wireworms. It is evident that using the broadcasting method of application 50 and 100 lbs. per acre of 5% powder are too low, and while 150 lbs. per acre has been fairly effective, higher dressings and different methods of application should be tried.

D.D.T. does not appear to be as effective as Gammexane against white grubs and to a greater extent wireworms, but the indications that it may have some effect on crickets is worth pursuing, since there was no indication that Gammexane affected these insects in any way.

References: Dawson, R. B., and Escritt, J. R. (1946), Nature 158. Golightly, W. H. (1946), Nature 158.

TIME OF PLOUGHING.

Mitchell's experiments attempting to manipulate the soil insect population by adjustment of the times of ploughing was continued. The following treatments were tested:—

(1) Land cleared July, 1945. Ploughed November, 1945. Planted to tobacco 9.12.45. Reploughed May, 1946. Planted tobacco 30.12.46.

(2) Cleared July, 1945. Ploughed March, 1946. Planted tobacco 30.12.46.

(3) Cleared July, 1946. Ploughed 15th November, 1946. Planted tobacco 30.12.46.

The treatments compared second year land, new land ploughed early while the soil was still wet from the preceding rains and new land ploughed late.

The loss of stand was analysed on 17th January, 1947. The results are summarised in Table VII.

TABLE VII.

Loss of Stand due to various causes in time Ploughing Experiment.

Treatment.	White Grubs.	Wireworms.	Crickets.	Causes Unknown.	Total.
1	273	114	110	124	621
2	352	146	173	86	757
3	210	128	147	110	595

Plots were 46 x 11 yards. Losses attributed to causes unknown were largely due to bad planting, sun scorch, etc.

Statistical analysis of the figures showed that the differences between the white grub populations were almost significant, treatment 3 being better than treatment 2. The wireworms and crickets were, however, unaffected by the treatment, the higher figures recorded for treatment 2 being purely fortuitous. The figures for the white grubs support the findings of Mitchell in the previous season. It is probable that to effect a worth while degree of control a still later date of ploughing is indicated.

VI

Laboratory and Field Chemical Investigations.

(By J. W. Thompson.)

A. ADDITIONS TO COPPER SPRAYS.

Introduction. Spraying growing tobacco with copper compounds is sometimes practised to control spotting diseases of the leaf. Experimental sprayings have been carried out throughout the Colony by Pest Control, Ltd., to test the possibility of spraying as a routine measure before the appearance of any disease. It was suggested by Pest Control, Ltd., that useful additions of nitrogen, phosphate and potash or trace elements could be made to the standard spray. The spraying of trace elements, and even nitrogen, phosphate and potash has been successfully used on other crops, but tobacco is exceptional in that only the leaf is harvested. This is the most sensitive part of the plant, and, in order to avoid any reduction in quality, damage to the leaf must be avoided. If a solution in contact with a leaf is more concentrated than the solution inside, moisture passes out of the leaf and the cell structure collapses. If, therefore, a strong solution is sprayed on the leaf, "scorching" of the leaf occurs. Again, if a weak solution is sprayed and forms droplets, which evaporate and concentrate the solution, damage may result. Dissolved salts in the plant have a tendency to move from the older to the younger leaves, which are consequently more resistant to spray damage. Normally a "wetting" agent is added to the spray to bring about the formation of a film of liquid over the surface of the leaf rather than a series of drops. Tobacco leaves have, however, a particularly "gummy" resinous surface which opposes the action of the wetting agent and strongly encourages the formation of drops rather than films.

Thus spray damage depends upon at least three factors:—

(1) The nature and concentration of the spray solution.

(2) The efficiency of the wetting agent.

(3) The age of the leaf.

Trials with Nitrogen, Phosphate and Potash Additions to the Spray.

In a preliminary trial with young plants in pots it was found that all concentrations down to ½ per cent. 10—6—8 fertiliser spotted the leaves, but that damage from ½ per cent. solutions was relatively small. On this basis the following details were adopted for the field trials:—

Blitox copper spray of constant strength was used as a standard, the treatments being varied by the addition of different amounts of N, P & K both collectively and individually.

TABLE I.

List of Treatments, Copper Spray plus N, P, K Additions.

1. 0.7% Blitox + 0.5% 10—6—8 fertiliser.
2. ,, ,, + 0.3% ,, ,,
3. ,, ,, + 0.1% ,, ,,

4. ,, ,, + 0.14% ammonium sulphate (equivalent to nitrogen in 0.5% 10—6—8).
5. ,, ,, + 0.28% superphosphate (equivalent to P_2O_5 in 0.5% 10—6—8).
6. ,, ,, + 0.12% potassium nitrate (equivalent to K_2O in 0.5% 10—6—8).
7. 0.7 Blitox; no additions.
8. No treatment.

A randomised block lay-out was used with six replications of each treatment. The plots were given an initial dressing of 150 lbs. per acre 10—6—8 mixture before planting to carry the plants on until they were sufficiently large for spraying. The plots were planted on 2nd January and sprayed on 5th February. Two days after spraying, the plants were scored for spray damage, with the following results:—

TABLE II.

Mean Number of Spotted Plants per Plot of 121 Plants.

Treatment	1	2	3	4	5	6	7	8
Spotted plants	12	7	2	9	14	5	2	1

Thus all except the most dilute N, P, K treatments caused spray damage.

The yield and quality results are summarised in Table III.

TABLE III.

Yields, Prices and Values from Copper Sprays plus N, P, K Additions.

Treatment.	Yield per Acre.		Price per Pound.		Value per Acre.			
	Lbs.	% of Mean.	Pence.	% of Mean.	£	s.	d.	% of Mean.
1. 0.5% 10—6—8	487	86.6	7.45	97.6	14	19	0	83.8
2. 0.3% 10—6—8	537	95.5	7.65	100.3	17	4	0	96.1
3. 0.1% 10—6—8	598	106.4	7.65	100.3	19	0	0	106.6
4. N.	652	116.0	7.74	101.4	21	3	0	118.1
5. P_2O_5	539	95.9	7.58	99.3	17	3	0	95.7
6. K_2O	592	105.3	7.70	100.9	19	0	0	106.6
7. Blitox	563	100.2	7.56	99.1	17	16	0	99.5
8. No treatment	525	93.9	7.69	100.8	16	16	0	93.8

No significant differences in yield, price or value.

	Yield.	Price.	Value.
Mean of treatments	562 lbs.	7.63d.	£17 18 0
Standard error	8.28%	1.49%	9.19%

An examination and statistical analysis of the results showed no indications whatsoever of a beneficial effect from adding nutrients to the standard copper spray. A solution of 0.5% 10—6—8 fertiliser at the

rate of 100 gallons per acre is equivalent to 5 lbs. of fertiliser per acre, and even this small amount caused appreciable spotting. The maximum amount that could be applied would be about 3 lbs. per acre. The prospects of achieving appreciable increases in yield by spraying dissolved N, P, K salts are therefore extremely remote.

Additions of Trace Elements to Copper Sprays. It has been shown in many crops that poor growth or certain spotting diseases of the leaves are due to a deficiency of trace elements. In many cases the deficiency can be corrected by spraying the plants with a solution containing the deficient element. While there are no obvious trace element deficiencies in tobacco, it was suggested by Pest Control, Ltd., that the incorporation of certain elements in the spray while carrying out routine spraying might have a beneficial effect. The following treatments were therefore tested.

TABLE IV.

List of Treatments, Copper Spray plus Trace Elements.

1. 0.7% Blitox + 0.1% Borax.
2. ,, ,, + 0.3% Manganese sulphate.
3. ,, ,, + 0.3% Zinc sulphate.
4. ,, ,, no addition.
5. No spray treatment.

A randomised block lay-out with six replications was used.

None of the trace element sprays caused appreciable damage.

All treatments received 150 lbs. per acre 10—6—8 fertiliser before planting, and a further 150 lbs. per acre four weeks after planting. Planting took place on 2nd January. The results are summarised in Table V.

TABLE V.

Yield, Price and Value from Copper Spray, Plus Trace Elements Treatments.

Treatment.	Yield per Acre.		Price per Pound.		Value per Acre.	
	Lbs.	% of Mean.	Pence.	% of Mean.	£ s. d.	% of Mean.
1. 0.1% Borax	726	97.4	7.96	101.0	24 4 0	98.5
2. 0.3% Man. Sulphate	738	99.1	7.79	98.8	23 19 0	97.8
3. 0.3% Zinc Sulphate	724	97.2	7.84	99.5	23 14 0	96.6
4. Blitox only	760	102.9	7.89	100.1	24 19 0	101.9
5. No treatment	776	104.2	7.93	100.6	25 15 0	105.1

No significant differences in yield, price or value.

	Yield.	Price.	Value.
Mean of treatments	745 lbs.	7.88d.	£24 10 0
Standard error	4.08%	1.85%	6.55%

The trace elements could only be expected to yield results in the almost complete absence of the elements concerned. Previous unpublished work at Trelawney on the application of trace elements mixed with the fertiliser has given negative results, and these are confirmed by the lack of response to the spray treatments given in this experiment.

It is of interest to note that spray damage due to manganese and zinc salts was slight, although the concentrations of the solutions used were relatively high. The absence of "scorching" was probably due to the formation of insoluble complexes with the basic copper compounds in the standard spray. If deficiency troubles were encountered, it would, therefore, be possible to spray adequate amounts of trace elements mixed with a copper spray.

B. PLANT HORMONE EXPERIMENT.

It has been well established that small traces of certain substances in the soil stimulate the growth of plants. Nearly all the substances used in practice are of a type known as heteroauxins. Indolyl acetic acid is the only one which occurs in nature, but several synthetic substances are known which are also effective, and preparations of some of these are sold under various trade names, mainly for use in trans planting cuttings.

Parker-Rhodes (Ref. 1) produced evidence to show that there are two regions of concentration in which the naturally occurring heteroauxin has a stimulating effect on plant growth in the case of wheat. At a concentration of 10^{-8} (i.e., about $\frac{1}{4}$ oz. per acre in the top 4 ins. of soil) the green parts are stimulated, and at 10^{-12} (about 1/40,000 oz. per acre) the roots are stimulated most. The usual concentration encountered is somewhere between these values—and the application of farmyard manure tends to increase the concentration.

It seemed possible, therefore, that the application of some of the substances at the time of transplanting might have a favourable effect on the amount of leaf produced by the plant.

Experimental Details. Four different commercial root stimulants were made up according to the directions on the packet and applied to the plants as they were taken out of the seed-beds. The four different treatments and control plots were arranged as a Latin square, giving 25 plots of 1/40 acre each. New land was used which was opened in the dry season of 1946. Fertiliser at 150 lbs. per acre, Standard 10—6—8, was applied on 2nd December, 1946, and 4 weeks later the plants were taken from the seed-beds and a further 150 lbs. per acre was added.

Results. There was no significant effect on the stand, which varied from 92 to 96 per cent.

After six weeks, two out of the four substances used appeared to have caused appreciably better growth than the controls and the other two preparations, but in the following final yield figures there was no significant differences.

TABLE VI.

Yields from Plant Hormone Treatments.

Treatment.	Yields (lbs. per acre).	% of Mean.
1	875	98.3
2	895	100.6
3	878	98.7
4	935	105.1
Control	867	97.4
Mean	890	

Discussion. Although the control plots produced the lowest average yield, the increases produced by the various treatments were very far short of statistical significance.

The results are no reflection on the trade preparations concerned, as effects were sought which were not claimed by the manufacturers. The substances sold commercially are primarily stimulants for root growth, but under suitable conditions it is quite possible that leaf production may be favourably affected. As such small amounts of the substances are effective, it is quite possible that an appreciable increase in yield can be obtained for a very small increase in cost, and work will be continued when possible.

(Ref. 1.—Parker-Rhodes, A. F. Journal Agric. Science, Oct., 1940.)

C. CYANAMIDE AS A MEANS OF CONTROL OF WEEDS IN SEED-BEDS.

Calcium cyanamide is used in America to control the growth of weeds in tobacco seed-beds instead of burning them, as is the general practice in this country.

The method of using cyanamide is to work it into the top 4 inches of soil at the rate of $\frac{3}{4}$ lb. per square yard, and to apply a further $\frac{1}{4}$ lb. per square yard to the surface. This must be done 60 to 90 days before planting the beds. The soil must be moist at the time of application and must also be well watered before sowing. It is claimed that the plants grow better and that weeding of the beds is eliminated. The calcium cyanamide used was a trade preparation known as Aero Cyanamid.

This method of sterilisation was tried, using the site of some of last season's seed-beds. Three treatments were used: control, cyanamide with initial watering, and cyanamide watered at intervals, the beds being covered with grass to conserve moisture. There were six replications of each treatment.

An excellent control of weeds resulted, the number of weeds on the treated beds being about 1 per cent. of that on the untreated beds. No marked difference was found between the two cyanamide treatments. The tobacco seed germinated satisfactorily, but failed to make satisfactory growth, due, it was found, to the treated beds being too alkaline. Burning of the seed-beds in the previous season had made the beds very slightly alkaline, but not to an extent which would interfere seriously with the growth of the plants. Cyanamide at the rate of 1 lb. per square yard, however, raised the alkalinity to a toxic level. If a slightly acid soil had been used, there would probably have been no trouble. It was found that the alkalinity produced by the cyanamide would be neutralised by the application of sulphur at about 10 grammes (1/3rd oz.) per square yard. The neutralisation was complete in about two weeks.

Trouble was encountered at other places where cyanamide was tried, but the cause was not specified. A survey of the vleis on the station indicates that trouble due to excess alkalinity would be frequent unless steps are taken to counteract it. In a wetter season the effect of alkalinity of the soil may not be so great. Experiments will be continued to determine suitable conditions for Rhodesia.

The total nitrogen and ammonia nitrogen in the treated and untreated soils were measured at intervals. The cyanamide was applied on 28th October, and after a large initial rise in both total and ammonia nitrogen, there was a decrease until about 15th February—i.e., after $3\frac{1}{2}$

months—when steady values were reached. The rate of application of cyanamide was equivalent to 1,000 lbs. of nitrogen per acre, and of this ¾ had been lost at the end of 3½ months (probably to the atmosphere, since the sub-soil nitrogen was unaffected). The amount of ammonia in the soil was raised from about 12 to 70 lbs. per acre.

D. CYANAMIDE FOR CONTROL OF EELWORM.

Cyanamide has been recommended for the control of eelworm in certain crops, and it was therefore tried as a method of controlling eelworm in tobacco.

The recommended rate of application is 1,000 lbs. per acre, half the dressing being broadcast and mixed with the soil by ploughing or discing. The remaining half is then broadcast and disced in. Again the soil must be moist for the cyanamide to be effective.

Twelve plots of 1/40th acre each were used, six being treated and six untreated. An appreciable reduction in the number of weeds resulted, counts showing the weeds to be six times as numerous on the untreated plots as on the treated plots. The treatment had no effect on the stand. Treated plots were fertilised with phosphate and potash only, but the tobacco was coarse and rank owing to the large amount of nitrogen supplied in the cyanamide (1,000 lbs. per acre cyanamide is equivalent to 200 lbs. nitrogen).

At the end of the season the plants were dug out and the roots examined for eelworm infestation. The infestation was equally heavy in both treated and untreated plots, indicating that the cyanamide was not effective against eelworm. The season was, however, an unusual one climatically, so the experiment is being repeated in the hope of securing better results in a wetter season.

In contrast to the seed-bed experiment, there was no residual nitrogen left in the soil by the cyanamide 3½ months after application; the percentage of nitrogen in the soil was as low as the initial nitrogen content. The ammonia content was, however, raised slightly from about 10 to 20 lbs. per acre.

E. THE CHEMICAL EFFECTS OF COMPOST.

Details of the field trial with various composts have been given in the previous section of this report. Chemical analyses were made of the five different lots of compost used, and, on the whole, the samples were above average Rhodesian quality and representative of widely differing types.

These analyses were confirmed on nearly all possible points by growing tobacco plants on mixtures of sand and compost and measuring the amount of N, P, K nutrient extracted by the plant.

Further analyses were carried out on the soil from the field plots, and it was found that increases in soil organic matter due to compost were small compared to the variations in organic matter already present in the soil. These chance variations of soil organic matter were sufficient to render any variations due to compost treatments statistically insignificant. As yield results were highly significant, it is not likely that soil organic matter was a major factor influencing yield.

Soil acidity (pH) was found to be significantly affected by compost, the most alkaline composts having the greatest effect.

Cured samples from the middle (4th) picking tobacco were analysed, and estimates made of the amounts of N, P, K contributed by the various

composts. The crop was found to be normal in respect to all the other elements for which analyses were made. As might be expected, the tobacco grown on compost only, without fertiliser, was very low in potash, phosphate and lime, which probably accounted for the meagre yield.

Discussion. The beneficial effect of compost on crops has been ascribed to some or all of the following effects:—

(1) Compost is a source of fertiliser elements nitrogen, phosphorus and potash.
(2) Compost makes the fertiliser elements in the soil more available to the crop.
(3) The organic matter has a beneficial effect on soil structure, reducing leaching of plant nutrient, giving better aeration, etc.
(4) Compost promotes the mycorrhizal association, whereby the feeding of the plant is facilitated.
(5) Compost is a source of heteroauxines, small traces of which in the soil stimulate root production.
(6) Compost may have a beneficial effect on the soil fauna and flora.

As stated previously, it is unlikely that the effect of compost was due to adding organic matter to the soil. Also, compost 2, which contained most decomposed organic matter, gave the smallest increase in yield. In a wetter season, aeration of the soil or fertiliser losses by leaching may be of critical importance, in which case the addition of organic matter might affect the yield.

This season's work has been concerned mainly with the first three possibilities only. It is hoped to include work on all the above possibilities in the following season.

The following chemical evidence strongly indicates that the increased yield brought about by compost in the particular season on the particular piece of land studied was primarily due to an increased supply of phosphate.

When tobacco is grown under conditions of moderate deficiency of a particular fertiliser component, the yield is limited by that component, and generally a lower percentage is found in the plant than would be found in a plant grown on an adequate supply. When the plant is grown with a surplus of a particular component, a surplus is taken up by the plant and generally a relatively high percentage is found in the plant. If the increase in yield due to compost is due to the compost relieving a deficiency of a particular element, it is likely that the percentage of that element found in the plant will be higher in the composted plots than in the non-composted plots.

Compost produced an increase in the percentage of phosphate in every case except No. 5, when fertiliser was omitted and the yield was least. The percentages of the other fertiliser elements were in most cases decreased by compost, indicating that they had been diluted by the increased growth, in spite of the extra amounts contributed by compost.

The major importance of phosphate in producing the increased yield is shown by these further points:—

(1) There is a highly significant positive correlation between yield and the percentage of phosphate in the leaf. (Correlation coefficient .541, significant at considerably less than the 1% point.) With all the other elements no such correlation was found.
(2) The correlation between the yield and the total amount of phosphate in the leaf is very close, but that for nitrogen is not so close.

(3) Only phosphate and lime percentages are markedly below average, but the lime percentages were decreased by compost, while the phosphate percentages were increased.

(4) The tobacco from the composted plots contained up to 40% more phosphate than that from the fertiliser only plots, and the yield increases were up to 30% greater. The increases in the other elements were all smaller. Further, the increase in yield brought about by a particular compost is very nearly proportional to the amount of phosphate supplied by the compost. No such relation exists for the other elements.

The increase in supply of the other elements is likely to have produced some increase in yield—particularly the increase, in some cases, of the nitrogen supply, since it has been established by previous work at this station that, over a wide range of rates of fertiliser application, the increase in yield produced by increasing nitrogen and phosphate supply simultaneously is greater than the total yield increase produced by both alone. Thus, the increase in nitrogen supply produced by composts 1, 4 and 6 will have contributed to the yield, and the reduction in the supply of nitrogen will have partly accounted for the smallness of the increase in yield brought about by compost 2.

It seems, therefore, that the increased phosphate supply has increased growth and diluted the nitrogen in the plants. It has been shown previously in America (reference 1) that an increased nitrogen content is accompanied by a decreased sugar content. With these samples, the same effect is observed, the negative correlation of sugar and nitrogen contents being very close. The phosphate supply only influences the sugar content indirectly, as the phosphate-sugar correlation is not nearly so close as that of nitrogen and sugar. Increase of percentage sugar is associated with an increase in quality (reference 2), lack of sugar indicating lack of maturity and, in the more extreme cases, the green, rank tobacco associated with excess nitrogen.

In the case of cigarette tobaccos, the term body refers to the content of soft, semi-fluid constituents which contribute to the weight of leaf without influencing its thickness or density of structure, and a leaf is said to be deficient in body when it is of a dry, chaffy nature (reference 2).

The resin content is part of the semi-fluid constituents, but it is only one-quarter of the sugar content, and perfectly dry tobacco is brittle, showing that oiliness is mainly due to water soluble constituents, the most important of which is some form of sugar. The sugar content is thus an important factor in determining the "oiliness" of tobacco.

It is possible that the increased phosphate supply is associated with the effect of compost on the pH of the soil. Phosphate is rendered unavailable in acid soils and compost decreased the acidity of the soil in the plots. The three composts, 1, 4 and 6, with the greatest effect on the phosphate availability, were the three with the high pH (8.3, 8.6 and 8.5 respectively), and the greatest effect on the soil acidity. The two composts with the least effect were 2 and 7, with pH at 7.2 and 7.3 respectively.

It has been suggested in previous reports (Tobacco Research Board's Annual Report, 1940) that the nitrogen and phosphate supplied to the plant must be balanced and that adding nitrogen to a balanced supply will not increase the yield unless a corresponding amount of phosphate is added. As nitrate is very easily washed out of the soil and phosphate is not, it follows that the proportion of nitrate supplied must be in-

creased in wet years, and that in very dry seasons a surplus of nitrate is probable. This explains the shortage of phosphate in this last season, and adds additional probability to the foregoing explanation.

Although the general level of phosphate percentage found in Trelawney tobacco from other experiments was rather lower than in previous seasons, the percentage of phosphate in the tobacco grown on the plots without compost and with fertiliser only was lower than that found in any other trial. The reverted land used was selected in the belief that it would give a maximum response to treatment with compost. The fact that yield response was due to increased phosphate supply and that the fertiliser only plots gave tobacco with a lower phosphate content than any of the other Trelawney experiments indicates that the land was well chosen.

Of 26 other samples of tobacco from various parts of Southern Rhodesia, six samples contained a lower percentage of phosphate than tobacco from the fertiliser only plots in the compost trial, indicating that other things being equal, yield responses equally large to those obtained in this experiment would only be obtained in the minority of cases.

It is possible that in a wet season the factors influencing the nitrogen supply will be more important than those governing the phosphate. The high carbon:nitrogen ratio of compost 2 (value 22) actually decreased the amount of nitrogen available to the crop. The analyses of the Rhodesian composts analysed in the Government Laboratory, Salisbury, indicate an average C:N ratio of over 20, which shows that a large proportion of the samples analysed would be very poor suppliers of nitrogen for tobacco.

Conclusions. It is evident that compost modified considerably the chemical composition of the cured leaf and makes substantial contributions to the major fertiliser element requirements. These requirements will vary, but for this season, and on the particular soil under discussion, the main effects of compost have been:—

(1) The phosphate supply has been increased, thereby increasing the yield. This is evident, since—
   (a) the phosphate percentages are low;
   (b) the additional phosphate supplied by the compost has *increased* the percentage in the plant;
   (c) there is a close correlation between yield increases and the increase in percentage phosphate found in the leaf;
   (d) previous experience makes it likely that phosphate will be in short supply in a dry season.

(2) The increase in growth produced by the better phosphate supply has diluted the nitrogen in the plant and lowered the observed percentage of nitrogen.

(3) The decrease in nitrogen has brought about an increase in sugar content, which is associated with an increase in quality.

(4) The potash supply has been increased, which improvement is associated with a cleaner leaf. In some cases the increased supply of potash could not compensate for the increased growth and the percentage of potash dropped.

It seems that the degree of breakdown of the compost is of secondary importance provided that the carbon : nitrogen ratio is at a suitable level. The carbon : nitrogen ratio decreases as the compost matures, and

the nearer the compost is to maturity, the more available is the nitrogen content unless nitrogen losses take place by leaching or excessive alkalinity.

From the analysis and appearance of the composts it is apparent that the methods of manufacture vary very widely. It is not yet possible to say which of these methods are most suitable for use with tobacco, but valuable indications have been found which, if followed up, should provide a sound basis for practical procedure.

The results also emphasise the importance of balancing the phosphate and nitrogen supply, which, in a dry season such as the last, often means avoiding excess nitrogen.

References—

(1) Darkis, F. R.; Dixon, L. F.; Wolf, F. A.; and Grus, P. M. Ind. Eng. Chem. 29-30. 1937.

(2) Darkis, F. R.; Dixon, L. F.; and Grus, P. M. Ind. Eng. Chem. 27; 1152-7. 1935.

VII

Thermal Efficiency Investigations.

The investigations and experiments in Thermal Efficiency during 1947 are, in this report, divided into two sections, (a) the electrical curing process, and (b) experiments with heating and temperature recording equipment used in tobacco curing barns.

The electrical curing experiments were begun as the result of an agreement reached some time ago, between the Salisbury Municipality, the Electricity Supply Commission and the Tobacco Research Board. We are indebted to these two bodies for their co-operation in the experiments, and the results given herein on Electrical Curing have been extracted from the reports of the Commission's engineers.

The Board's engineer conducted the tests and experiments in the second section of this report, and the data submitted to the Board from time to time during 1947 form the subject matter of this section of the report.

PART I.

Electric Curing of Tobacco.

By THE TOBACCO RESEARCH BOARD OF SOUTHERN RHODESIA

1. **Experimental Work.** In August, 1945, the Tobacco Research Board invited representatives of the Salisbury Municipality and the Electricity Supply Commission to meet the Board to discuss a report by Mr. J. S. Clinton, former City Electrical Engineer of Salisbury, on the possibility of the application of electricity to curing Virginia Tobacco in Southern Rhodesia. It was decided at this meeting that a full-scale experiment should be carried out on a standard 16 x 16 x 20 ft. tobacco barn, the Electricity Supply Commission and the Tobacco Research Board each to bear 50 per cent. of the cost, whilst the Salisbury Municipality would loan equipment and instruments and provide the electrical power connection.

It was not until early this year, however, that the plant was ready for operation, and the experiment could commence. About 30 acres of tobacco had been planted at the Hillside Experimental Station, Salisbury, and in spite of the difficulties created by drought conditions, over 5,000 lbs. of tobacco were successfully cured. A full and detailed account of the experiments is at present being prepared jointly by the Electricity Supply Commission, who conducted the technical investigation, and the Tobacco Research Board, who supervised the tobacco curing—and this report will be made available in due course.

Since this report is likely to take some considerable time to prepare for publication, however, and because certain broad conclusions have already been reached and will not be materially altered subsequently, the Board feels that immediate publication of these conclusions would be of some value to the industry.

The primary objects of the tests were:—

(a) To verify that there would be no major difficulties in applying electricity to tobacco curing.

(b) To determine the factors which affect the economy of curing by electricity.

(c) To evolve a simple and efficient technique for general application.

As a result of the work carried out, it has become evident that electrical curing of tobacco is an economic proposition, subject, of course, to the stability of the tobacco market, and that certain fundamental principles must be adopted in the lay-out and design of barns operated by electricity for maximum economy.

It is proposed, therefore, to describe in brief the underlying requirements.

2. **Choice of Process.** Tobacco curing being fundamentally an "intermittent" process—that is to say, each charge of tobacco is treated on its own and in an entirely different manner, perhaps, from the next charge—it would not be possible to apply a continuous process such as a long tunnel, with the tobacco being fed in at one end and being removed, cured, at the other. The main consideration, therefore, is the size of the charge, and the most suitable dimensions of the single barn unit required to accommodate it.

It would be a reasonable assumption to suppose that as a result of the experience of the tobacco industry over past years, the 5,000 lbs. green weight unit—sufficient to pack a 16 x 16 x 20 ft. barn—was found to be the most economic size of unit as well as being the largest quantity of tobacco that could be cured reasonably well in one barn with present methods.

However, with forced air circulation as used in an electrical barn, there appears to be no reason why barns should not be packed more tightly, and this can be done by dispensing with the orthodox method of tying sticks, and substituting the following:—

Each 4 ft. stick would be provided with about 90 simple clips into which leaves could be fastened as they are picked in the lands. The sticks would be loaded on to wagons provided with a covered framework in which to hang them, and upon arrival at the barns the sticks would be packed directly into position in the barns.

It is estimated that the weight of tobacco in each barn could be thereby increased threefold—thus giving an output of about 3,000 lbs. of cured tobacco per run.

The advantage of increased output from the point of view of electrical curing would be, firstly, that fewer barns would be required for a given acreage of tobacco, resulting in a reduced capital expenditure on barns and equipment, and secondly, the standing heat losses on the barn would be divided over the larger output, resulting in much lower running costs per pound of cured tobacco.

The major limitations to increasing output, however, would appear to be the availability or otherwise of sufficient ripe tobacco in the lands when required, and the size of the labour force needed to reap this amount of tobacco in one day.

3. **Arrangement of Barns.** The primary consideration here is the reduction of heat losses from walls to the outside atmosphere, and in order to have as small an outside wall area as possible, barns would be arranged side by side and back to back—a four-barn unit being the most convenient. If the method of packing suggested above proves possible, a four-barn unit could handle the tobacco of 12 ordinary barns.

The losses from outside walls can be still further reduced by arranging the bulking sheds for these units around the barns generally as depicted in Fig. 1.

The choice of the position of the grading sheds is further influenced by the fact that the discharge of moisture-laden air from the barns will be to the grading sheds, making it unnecessary to introduce any other means of general air conditioning during the curing period.

It is estimated that the maximum amount of heat insulation required will be cavity walls on the outside of the unit and special heat insulation applied to the roof in the form of a ceiling. The inside walls would need little more than a water-proofing coating to prevent moisture absorption.

4. **Air Circulation and Heating.** During the experimental work a great deal of information was ascertained in regard to the manner in which air circulated within a tobacco barn, and as a result of this experience, the present system has been designed. (See Fig. 1.)

It is found to be essential to force air into the tobacco at as many points as possible, and for this reason an air distributing column is located up the centre of the barn. Air under static pressure is projected from slots in the column between each layer of tobacco, and the column is so designed that the air quantity flowing into the bottom layers is greater than at the top, in order that the general condition of the air throughout the barn should be approximately uniform.

Advantage is taken of the natural tendency of air which cools on absorbing moisture from the leaf, to fall, and the withdrawal of air from the barn therefore takes place at the bottom.

The air quantity used would be approximately 2,000 to 3,000 cubic feet per minute, and the fan would be located just outside the barn.

The heater units, comprising approximately 50 K.W. of spiral type heaters, would be located in the supply trench to the central column. A portion of these heaters will be fixed in capacity and switched on manually as required, while the other portion would be operated automatically by a thermostat to maintain the temperature of the barn constant.

The method of control adopted is such that whereas a divergence of five degrees can be allowed in the temperature of the supply air, the temperature in the barn itself would vary very slightly, if at all.

5. **Heat Economising.** An essential part of the process consists in utilising the moist air ejected from a barn which is drying, to condition a barn which is yellowing at 90 to 105 degrees F. This is accomplished by providing what can be called a by-pass duct running under all barns and into which unwanted air can be discharged. This supply of air will be available to all barns, and its condition will be suitable for barns which are yellowing at low temperatures and require a supply of saturated air.

Furthermore, it is proposed to run a galvanised iron or copper pipe along the length of this trench through which comparatively dry atmospheric air can be drawn. A considerable amount of pre-heating of the air enclosed in this pipe will take place owing to the heat and condensation of the air around it. Barns which are in the process of drying would draw on this atmospheric air exclusively whilst discharging their moist air into the by-pass duct.

The electrical heating of barns which are yellowing will therefore be negligible, being confined to the small amount necessary to keep the barn temperature constant. Power requirements would be increased, however, at the commencement of drying, even though the air supply at this stage will have been considerably pre-heated before use in the barn.

6. **Description of Process.** When the barn has been filled to capacity, the fan is started up and the air control set to draw moist air into the barn from the by-pass duct. The controlling thermostat is set to the temperature required, and the barn and contents allowed to get up to temperature. During operation at 90 degrees to 105 degrees the temperature of the air in the by-pass duct should need very little adjustment, and only a small amount of power would be required.

When the leaf is sufficiently yellow and colour fixing is commenced, the air supply is changed over so that the fan is drawing from the atmospheric air main and the barn is discharging into the by-pass duct. Heater capacity has now to be increased to contend with the higher temperature required in the barn.

During this part of the process moist air is expelled from the barn into the by-pass duct, where it cools to a certain extent, giving up some of its heat to the atmospheric air main, and becoming saturated. Part of this supply of air is re-used by other barns in the yellowing stage, whilst the surplus is discharged into the grading shed.

The atmospheric air supply is drawn from the grading shed, and it is worth recording that even if this air is saturated at 90 degrees F., it is sufficiently dry at higher temperatures for injection into barns that are drying.

After the web of the leaf is dry, and drying of the midribs is to be commenced, the air supply in the barn is re-circulated without the admission of any additional air until the midribs are thoroughly dry. It is anticipated that with forced air injection the time taken to complete this part of the process should be reduced over present methods and drying at lower temperatures might be possible.

In order to cool the barn and condition the tobacco, the air supply is again drawn from the moist by-pass duct and circulated through the barn until the tobacco is in a suitable condition for handling.

The air change-over control is manipulated by hand near the fan, and is merely a system of opening and closing the appropriate vents to obtain the direction of air required.

7. **Costs.** The cost of equipping a barn for electrical curing would naturally be greater than the cost for the ordinary flue-curing process, but this is offset to a large extent by the fact that the output of the electrical barn is estimated to be at least twice that of the conventional barn, and less than half the number would be required.

In regard to running costs, experiments showed that the electricity consumed by a single singly isolated barn was approximately 3,200 units of electricity per curing. The saving due to the economy of exposed walls alone would amount to approximately 15 per cent., or 480 units. The heat exchange system adopted is expected to effect a further reduction of approximately 1,000 units in electricity consumption, thus bringing the total figure of 1,720 K.W.H. per barn.

Calling this estimate 2,000 units, and once again placing the output of the barn at double that of the conventional barn, it is expected that the power consumption can be reduced to one unit of electricity per pound of cured tobacco.

It is necessary to mention that with twice the quantity of tobacco in a barn the overall heat or power consumption is not double by virtue of the fact that major portion of the heat used to evaporate water from the leaf is not lost to the system. Part of the heat is given up to the atmospheric air main by direct conduction and by the condensation which takes place in the by-pass duct; part of the heat

is re-used in maintaining one or two barns at 90 degrees to 105 degrees F., and the remainder is passed to the grading shed, where it can still serve a useful purpose in maintaining a humid air condition. The total losses on the system are those represented by the heat escaping from the grading shed or being conducted away through the walls of the by-pass duct, and, of course, the walls of the barns.

Conclusions. Based on experience gained with electrical curing of tobacco, a process has now been put forward for economic curing, with the following salient features:—

1. Barns are arranged in blocks of four with bulking and grading sheds attached around the perimeter.
2. Tobacco will be picked and clipped directly on to sticks in the land and transported to, and placed straight into, the barn.
3. Forced air circulation through the tobacco will enable a much tighter pack, and it is estimated that the limit is of the order of three times the normal barn corresponding to about 90 leaves per stick.
4. A system of heat transfer from a barn discharging moist air to one requiring low temperature high humidity has been adopted to give maximum economy of heat.
5. Automatic temperature control is utilised.
6. It is estimated that the output of an electric barn could reach the maximum of three times that of the standard flue-cured barn, and therefore affecting a considerable reduction in the number of barns required under present conditions.
7. With the increased efficiency derived from electrically heated barns, the cost of curing tobacco should compare favourably with the present methods of curing.

PART II.

Barn Heating and Temperature Recording Experiments. The experiments and tests in barn heating and temperature recording carried out during the past season were all sited at the Board's "Hillside" Station.

A crop of tobacco had been planted for use in the experiments connected with electrical curing processes, and it was decided to carry out parallel tests with coal-burning furnaces and other methods of heating tobacco barns, using leaf not required for the electrical experiment.

By arrangement with the Rhodesia Tobacco Association facilities have been provided throughout 1947 for members of the Association to visit the Hillside Station every Wednesday afternoon to inspect all the experiments reported upon hereunder.

Advantage has been taken of this facility by many growers, who have been able to inspect the work in progress.

Four barns were available, 12 ft. x 12 ft. x 16 ft., and where comparisons of cost are quoted in this report, the size of these barns, smaller than the average, should be borne in mind.

A Coal Burning Furnace. In December it was agreed to build a more modern type of furnace which would be, as far as possible, a departure from the farm-brick, open-furnace type in common use in the Colony.

Accordingly a cavity wall furnace was constructed incorporating a baffle wall and expansion chamber. It was hoped that the simplicity of the design and its clean lines would encourage growers to copy this type of furnace. The cavity walls would, it was hoped, reduce the risk of cracked brickwork which normally would require repair each season. The expansion chamber would, to an extent, eliminate burnt curing flues, and the whole reduce the consumption of fuel.

The furnace was designed primarily to burn household coal: anticipated to be the future heating medium for tobacco barns.

In addition to the air drawn through the fire bars, provision was made to provide extra air over the surface of the fuel bed. In this manner almost complete combustion of the furnace gases was expected, and the soot deposited in the flues could be reduced to a minimum. The heat-radiating effect of the flues could be maintained at a high level

It is not proposed to go into detail over the design and construction of the furnace, for no new features were involved. Well established engineering principles only were used, with the sole objects of fuel conservation and economy of operation.

Fire bricks were used instead of farm bricks for the inner section of the furnace, and locally made furnace fronts and firebars were used throughout.

A model of this furnace was made and exhibited at the 1947 Salisbury Agricultural Show, and a full report was published in the "Rhodesian Farmer."

Because, in the past, no experiments have been carried out by the Board in comparable circumstances, tables of comparisons from cost and consumption cannot be given this year.

Where possible, however, costs were computed for each experiment, but in particular respect to the columns 2 and 3 can only be regarded as approximate.

The tobacco curing costs of the furnace described in the foregoing text (to be known for purposes of identification as the "T.R.B." furnace), are shown in Table I.

TABLE I.

1	2	3	4
Price per ton of fuel.	Cost of brickwork.	Cost of furnace parts.	Average cost of curing 1 lb. (dry wt.) of tobacco.
31/-	£8 0 0	£12 10 0	0.68 pence.

The average price per lb. dry wt. is based on 9 separate curings.

The soot taken from the flues after each curing appeared, by report, to be much less than that expected.

The results anticipated by the designer at the commencement of the season in regard to this furnace were fully realised. There was no evidence of badly cracked brick work, and throughout the curings on no occasion did the flues become red hot Fully detailed drawings of the design, and data dealing with the construction of this furnace, may be had on application to the Secretary, Tobacco Research Board, P.O. Box 387, Salisbury.

Automatic Stoker. An electrically driven automatic stoker of English manufacture was installed at the beginning of the season. This

model had been in use for a full season the previous year. The design provided for the coal, gravity fed from a hopper into worm-gear, to be conveyed into the base of the fire-basket.

A thermostatic temperature control was fitted by which the barn temperatures could be automatically controlled to within $2\frac{1}{2}^{\circ}$ F. of the set figure. Pea-coal was used, and excellent combustion was obtained. The stoker proved a complete success in regard to ease of operation, and a minimum of ash was left in the fuel chamber. Lack of electrical current brought this experiment to a premature close at the Station, but sufficient data had by then been obtained to show the feasibility of heating tobacco barns by this method.

The table of costs is shown in Table II.

TABLE II.

1	2	3	4
Price per ton of fuel.	Cost of brickwork.	Cost of furnace parts.	Average cost of curing 1 lb. (dry wt.) of tobacco.
26/-	£20 0 0	£135 0 0	0.63 pence.

The figure given in column 4 was based on 5 curings.

Note.—The furnace was constructed of firebricks throughout.

Acknowledgements. We are indebted to Messrs. Johnson & Fletcher, Salisbury, for providing the stoker and constructing the furnace.

Thermal Conditions in Barns. Realising that in the past little had been recorded on temperature variations inside tobacco barns, it was resolved to make an attempt during the season accurately to plot the rise or fall of temperature due to human or weather conditions.

For this purpose an instrument was installed which comprised thirteen electrical thermometers of the resistance type, which were installed in various parts of the barn. These were wired to a recording device situated in an adjacent building, so that readings could be taken at all hours without entering the barn.

Over four thousand readings were taken and plotted, and several most interesting facts emerged.

It was found that the opening of the barn door to allow water to be poured over the sacks on the floor caused a 10° drop in temperature in the centre section of the barn.

Sun effect on the roof was found to cause differences in temperature in various parts of the barn, particularly among the higher tiers of tobacco. A steady rise in temperature was noted as the day progressed, with a corresponding fall during the hours of darkness.

A measure of success in drawing away the hot air formed under the roof, was obtained by placing a 3 inch steel pipe from the eaves and leading it to the chimney base.

A heavy rainstorm, driven by wind on the one side of the barn, was found to cause a drop in temperature of 13° from the top to the bottom of the barn on the exposed side. This was found to be due to leaks in the eaves. When these leaks were bricked up the temperature variation was considerably reduced.

A similar instrument, incorporating a device that measures the $C.O._2$ content inside the barn has been ordered, and more exact data should be available after a further season of experiments.

Acknowledgements. The multipoint electrical distance temperature indicator was kindly loaned by K. B. Davies & Co., Ltd.

MISCELLANEOUS EXPERIMENTS.

Gas Producers. Investigations were inaugurated into the feasibility of heating tobacco barns with a furnace using producer gas, which was designed to determine the value or otherwise of using this type of heating. Owing to the late start made upon this line of investigation no figures or final results can be shown. The experiment will be continued during the next curing season.

Farmers' Boiler. The need for an inexpensive and easily operated boiler for the tobacco farmer has long been recognised by the Board, and an attempt was made during the season to design one which would be light and portable (below 200 lbs.), which would have a low initial manufacturing cost, and on which maintenance could be reduced to a minimum.

A boiler was designed consisting principally of a tubular element, built up of ordinary water piping, with standard water pipe bends at the corners, so designed that the element could be placed on any suitable fire hearth or in any chimney, with a small water container which could be placed above the level of the element. The boiler could be used in any part of the farm where a simple farm brick structure could be erected. Wood was to be the heating medium.

It was found that the element would quickly provide steam enough to condition a barn of tobacco, or could be used with equal success in the grading shed, where a steady flow of low pressure steam was required.

The results of the tests made were most encouraging, and this line of work will be pursued during the coming season.

Humidification. A tubular humidifier, adapted from well-known principles, to be used in conjunction with the previously described farm boiler, was also constructed.

The humidifier, made of tubular steel, has an overall length of 6 feet with a 2 inch diameter, and being of light construction this could easily be taken from barn to barn as required. The interesting feature of this experiment was, that using the humidifier alone, a barn of tobacco was successfully wilted, the furnace not being lit until the second day. Wet sacks on the floor of the barn were eliminated.

Oil Heating of Barns. In spite of the advantages of oil as a heating medium the high cost per gallon of fuel is a factor which must militate against its general use. However efficiently it burns, the fact remains that 1 lb. of oil has the equivalent heating value of 1½ lbs. of coal, so that as we require one ton of coal to cure a barn of tobacco, 1,332 lbs. of oil at the current local price of 1s. 1d. per gallon our costs become £8 9s. 0d. per barn for fuel alone as against the price of household coal at approximately £2.

However, it was decided to carry out experiments in oil heating of barns in the nature of a long term policy or as an efficient substitute for electric current should the latter fail.

Work was carried out in heating barns with an oil pressure sprayer manufactured in the Union and adapted to a standard furnace. Considerable difficulty was experienced in controlling the barn temperature with this oil under pressure and the conclusion was quickly reached

that with steam atomisation of oil, European supervision was essential. Accordingly to reduce the difficulties experienced in controlling the temperature a simple oil burner was evolved working on natural draught and needing no pressure. The system of fuel introduction into the furnace was by gravity, and the flow of oil on to a burner plate could be easily controlled. Difficulties of control when low temperatures were required in the barn proved that further modifications to the design would be necessary during the forthcoming season.

Experiments with rectangular, instead of circular iron flues, were carried out during the season. No tabulated results on this experiment are yet available.

Tests with aluminium, as opposed to black iron flues, and investigations into curing tobacco by direct heating methods were also carried out. The time factor has prevented these experiments from being brought to a conclusion, or tables of costs to be published. It is confidently anticipated that after the second season all this information will be available.